TOPICS OF THE MONTH

Nuclear development in Britain

MORE nuclear research and development work for industry is the theme of the report of the Select Committee on Estimates which has been studying the operations of the United Kingdom Atomic Energy Authority's Production Group and the Development and Engineering Group. As we go to press, the U.K.A.E.A. has issued no official commentary on the Committee's recommendations, but some of its leaders must be thinking hard about the suggestion that the big nuclear contracting consortia should be given a chance to get in on reactor development at an earlier stage, perhaps even being entrusted with the development of complete reactor systems. The Committee feels that, unless more of the scientific work is passed to industry, a situation will be created where the nuclear engineering industry will be under-employed as it is at present, while work it could do is having to be postponed by the Authority owing to shortage of scientific manpower.

Until now, the U.K.A.E.A. has jealously guarded a good deal of the scientific work involved in the initial stages of a reactor project, feeling that the engineering groups have not yet acquired sufficient experience to tackle this work competently. However, the present unhappy situation of the construction consortia, who just have not enough work to keep their skilled staffs occupied, might provide the incentive for a relaxation of this policy.

The Committee's report, no more than the recent annual report of the U.K.A.E.A., or the annual reports of the individual construction consortia, gives no fresh hope for any immediate change in the present uncertain position of these consortia. With no immediate prospects of further orders at home, and an export market that has not so far come up to expectations, the only hope of the consortia seems to lie in some sort of collaboration which would lighten the heavy burden of expenditure on research and development which each of them has to bear.

As for future export prospects, while a fall in the price of uranium might place British firms in a favourable position to export reactors using natural uranium to the Continent of Europe, the most attractive target for exports is undoubtedly the underdeveloped countries, and all efforts must be made to advance low-capital-cost systems such as are most likely to be accepted in such countries.

Putting the squeeze on cement

LATEST triumph of chemical engineering in the cement industry is the use of plate-and-frame filter presses to dewater cement slurry before it is dried in the kilns. The process developed by British Portland Cement Manufacturers Ltd. and put into operation at Shoreham, Sussex, is believed to be the first successful system in the world to use plate-and-frame presses in cement manufacture. Although rotary vacuum filters are used for this operation in some countries, notably the U.S., B.P.C.M. decided that the better moisture extraction obtainable with plate-and-frame equipment would more than outweigh the disadvantages of batch operation.

After a prolonged period of trial, adaptation and modification, the system has now been improved to a point where the moisture content can be reduced from about 42% to between 18 and 19%. (22% is the figure generally obtained with rotary filters in the U.S.)

The installation at Shoreham consists of three 48-in., 80-leaf presses operating at a filter pressure of 120 p.s.i. Each press is dropped about 17 or 18 times every 24 hr. and deposits about 10 tons of cake at a time, giving the plant a capacity of 3,000 to 4,000 tons/week.

The filter cloths are nylon. After experiments it was found that the most satisfactory results were achieved with a 12½-oz./sq. yd., continuous-filament, plain-weave fabric. Although the initial cost is high, it has a very long life as a result of the material's tensile strength, abrasion resistance and immunity to rotting. The cloths are hosed down in the press room about once a fortnight and there has been no trouble from blinding. Records kept during a period of 12 months showed that the average initial life of a nylon cloth was 2,000 pressings and that its total life after repairs was 3,000 pressings during which time it handled about 375 tons.

Liquid hydrogen as a coolant

THE high heat-transfer rates obtainable at sub-critical pressures with a forced-convection nucleate-boiling or even film-boiling process are attractive for use in cooling components of rocket motors, nuclear reactors, and other heat exchangers in space vehicles. For many applications a knowledge of the maximum nucleate heat-transfer rate (boiling burnout) and of film-boiling heat transfer is required. In addition the quality of the fluid at burnout may be of importance for a particular application. Many studies of boiling burnout have been made using more or less conventional fluids; however, little data are available for the cryogenic fluids. Empirical heat-transfer correlations for various fluids have not met with significant success; consequently, much uncertainty exists in predicting peak nucleate, as well as film-boiling, heat-transfer rates for the cryogenic fluids of interest for space vehicles.

The purpose of a study conducted at the Lewis Research Center of the National Aeronautics & Space Administration (U.S.) was to determine the heat-transfer rates in the nucleate and film-boiling range

using liquid hydrogen as the working fluid. The heat-transfer rates were measured with liquid hydrogen flowing vertically upward in an electrically heated, vacuum-jacketed tube. The heat-transfer rates were measured in the stable flow region for a range of flow rates from 5 to 25 lb./hr., inlet pressure of 30 to 70 p.s.i.a., liquid sub-cooling at the inlet from 0 to 6° F., tube diameter 0.555 in., and length-to-diameter ratios associated with the peak nucleate heat flux from 1 to 20. The resulting peak nucleate heat flux values ranged from 8 to 34 $\times$ 10^4 B.Th.U./hr./sq. ft. while the highest heat fluxes in the film-boiling region were about 50% greater. Thermodynamic fluid qualities at burnout ranged from 0.01 to 0.78.

This work was described at the Cryogenic Engineering Conference, held at the University of California early this month, by U. H. von Glahn and J. P. Lewis. Data were presented in graphical form and in terms of several correlation parameters which include the flow condition, heating rate, tube geometry, and fluid properties. The empirical correlation developed for the peak nucleate heat flux permits a comparison of the hydrogen data with data from studies using water and limited data from a study using liquid oxygen as the working fluids. An empirical equation was also developed by use of which the tube-wall temperatures downstream of the peak nucleate heat flux (*i.e.*, in the film-boiling region) can be predicted for hydrogen.

Bags for bunkers

IN emptying large bunkers or silos it is often necessary for bridges or voids in the charge, which impede the free flow of material, to be shifted by inserting manually or mechanically operated pokers to dislodge the mass from the bunker walls. Sometimes the operation even involves lowering a worker into the bunker to do this and, while there may be some workers who enjoy such tasks, the process cannot be said to be safe or efficient.

Inflatable rubber bags can now be installed in bunkers so that, when inflated, they exert a pressure on the material from behind, causing it to break up. The force exerted by a bunker air bag of standard size is about 32 tons—enough to shift the charge even where the material is relatively sticky.

The air bag consists of an iron base and a soft rubber diaphragm about 12 mm. in thickness. The diaphragm is securely attached to the base plate by a metal flange and is inflated to hemispherical shape using compressed air at 2 to 4 atm. The compressed-air supply is controlled by a push-button device connected to a pressure-equalised valve. The air bags can either be mounted on the internal walls of the bunker or countersunk into the structure, and can be brought into operation individually. The number of air bags required depends on the size and type of the bunker as well as on the grain size, moisture content and various other properties of the charge.

These air bags were described in a recent issue of *Rubber Developments*, according to which it is impossible to burst a bag because a safety valve is built into the centre of the base plate which is opened automatically by the rubber cords attached to the soft rubber diaphragm as soon as the permissible volume of air has entered the bag. There are other safety features. The bags are manufactured by Franz Clouth, Rhenische Gummiwarenfabrik A.G., Germany.

Mystery of the ironsands

MILLIONS of tons of magnetite ore lie wasting along New Zealand's west coast beaches. The sand also contains vanadium and titanium. A serious attempt is now being made to exploit this vast wealth potential; the New Zealand Government is sponsoring a research company to investigate the ironsands, and the prospects for an iron and steel industry founded on them.

Such an industry would cost £30 million and the Government is proceeding with understandable caution, for as was recalled in a recent article in the *Otago Daily Times*, others in the past have thought they had an answer to this riddle of the sands. For instance, there was the Cornish ironmaster, Perry, who went to New Zealand as an immigrant carpenter and noticed the iron in the Taranaki shore sands. He set to work to smelt some, using a crude furnace, which produced sufficient pig-iron for a sample to be sent to England, where it was turned into ' steel of surpassing excellence.' Some of it was tested by Moseley Ltd., a prominent London cutlery firm, whose enthusiastic reports led to the formation in 1861 of a London group—the Taranaki Ironsands Co.—with a capital of £150,000. But the Maori Wars of the 1860's caused delays. The company went into liquidation without starting operations of any kind in New Zealand. From then on, various enterprises were launched, and private companies formed, both in New Zealand and in England, to exploit the sands.

All came to nothing, in spite of the production of several thousand pounds' worth of high-grade pig-iron, which found a ready market. The ironsand proved reluctant to yield its ore. It was, in technical terms, ' intractable '—the iron tending not to run freely, but to choke the furnaces. Much difficulty, also, arose from impurities, especially the titanium; while in later years the lack of an abundant supply of cheap electricity precluded the use of modern techniques.

In the 1930's Electric Steels Ltd., of Sheffield, put forward their new *Cresil* process, claimed to be competent to deal commercially with the New Zealand ironsands, and were granted a licence to use the sands for iron and steel manufacture, but nothing came of the scheme. Shortly afterwards, the Duffield Iron and Steel Corporation, London, proclaimed its new process for treating New Zealand's beach ores and negotiated for shipments of Taranaki sand. This venture, also, came to nothing. A similar process had been tried, in fact, by a Taranaki pioneer, Mr. E. Metcalf Smith, back in the 1850's. It was Smith who discovered a method of ' briquetting ' the sand with clays to prevent furnace choking, by which he and others produced, in

experiments ranging over a 30-year period before 1900, some 300 tons of high-grade iron, which was cast and forged locally into a variety of useful articles.

At Wellington in 1870 Metcalf Smith floated his New Zealand Titanic Iron and Steel Co. Ltd., the first real attempt to establish an iron industry in New Zealand. But the company had a capital of only £20,000, and the venture collapsed for lack of funds.

The company which the New Zealand Government is promoting this year should have better luck, for it will have £250,000 for exploration and investigation work alone.

Colourful engineering

PUBLIC taste demands that peas shall be green and strawberry jam red, so, as the natural colouring matters of many foods are impaired during processing, the food manufacturer goes to the trouble of satisfying the consumer by using synthetic colouring. Helping to make it all possible, as we might have guessed, is chemical engineering. The August issue of *Food Manufacture* contained a lucid account of synthetic colour manufacture at I.C.I.'s Dyestuff Division works at Huddersfield.

Some 25 *Edicol Supra* food colours, some of them mixtures, are produced in the I.C.I. plant, which takes up only a small part of the 250-acre Huddersfield site. The plant occupies three floors and process movement is from the top downwards, mainly by gravity. On the top floor are some rubber-lined mixing tanks and filter presses which are used for filtering solutions in process as required. All raw materials are delivered to this floor by lift.

On the floor below are the coupling tanks, also rubber-lined, in which the manufacture of azo dyes is carried out. Of the 16 different colours made in this plant, nine are azo dyes. The connections between the tanks on the top floor and those on the floor below are by means of flexible rubber hose, allowing different tank combinations to be used. The tanks are fitted with electrically driven, slow-speed stirrers. Many coupling reactions require ice cooling, and for this purpose ice is obtained from the central refrigerating plant which supplies the whole of the Huddersfield works with ice or cooled brine.

On the ground floor are the storage tanks, enamel- or rubber-lined, which discharge their contents under pressure to filter presses on the same floor. The filter presses are of the multiple-frame type and filter off the precipitated dyes from the reaction liquors. After filtration, the filter presses are opened and the filtered dyes emptied on to trays. At this stage their moisture content varies according to the type of dye, and may be as high as 50%. The moisture is removed by drying in atmospheric steam-heated dryers, each of which has a capacity of about 2 tons depending on the product. Air heated by steam in heat exchangers is fan-circulated over the trays containing the product. After drying, the trays are emptied by hand into drums in an emptying cabinet so draughted as to prevent contamination of the operator.

Krypton caged

A NEW process of producing a clathrate, or inclusion complex, consisting of atoms of radioactive krypton locked inside a crystalline structure, seems to offer a means of obtaining sources of radioactivity which can be used with a far greater margin of safety in many industrial and laboratory applications than has been possible hitherto. In the process which Tracerlab Inc., U.S., claim to have perfected, hydroquinone is crystallised in the presence of gaseous Kr^{85} so that, as the crystals form, atoms of krypton become trapped within the interlocking network of molecules. The crystal structure does not interfere with the radiation emitted by the radioactive krypton but it does contain the krypton just as effectively as a thick-walled pressure cylinder.

Jargon and information

'SCIENCE,' writes a reviewer in the *New Scientist*, 'has influenced literary style and scientific writings provide some of the best examples of lucid and vigorous English prose.' And all one can say to that is heaven help English prose. Certainly the author of this surprising statement does not contribute a conspicuous example of lucid prose and few technical editors who, for their sins, are compelled to translate scientific jargon into English, would describe the majority of contributions they receive as lucid.

Often, the very desire to make accurate statements befogs the issue: it is, of course, a well-known fact that jargon increases as the square of scientific knowledge, and as the cube of specialisation. This last sentence is ours, but can serve as an example of the kind of mud which scientists churn up in their attempts to be precise. On the face of it, we have here a statement of a mathematical relationship; but how do you measure specialisation? And what is the cube of something you cannot measure?

In the whole field of science and technology there are probably no worse offenders against the rules of clear writing than engineers; for they pick up two kinds of jargon—one from the scientists, the other from the workshops—and to show that they are equally familiar with theory and practice, they use both languages, quite impartially.

Another frequent cause of turgid technical writing is an attempt to qualify each statement in the hope of achieving ultimate precision. But here, as in so many walks of life, a law of diminishing returns holds good. It is a kind of *Heisenberg* principle of uncertainty; you can go so far and no further in defining and describing; beyond a certain point, what you may gain in accuracy is more than lost in clarity. Hence the large number of technical papers which are unexceptionably accurate and clear as mud.

What is the solution? One almost despairs of finding one.

Symbolic languages have been invented from time to time, beginning with simple numbers and still going strong with two dozen rival computer codes, several of

which are called common languages! Symbols are all very well so long as they are clearly defined. What a relief it would have been to Pythagoras if he could have said simply: $c^2 = a^2 + b^2$. Nowadays the kind of algebra we need makes the printed page (assuming one can persuade a printer to set it) look like a knitting pattern. And if a symbol slips half a line out of place, it makes nonsense of the whole expression.

Perhaps lucid writing in science and engineering will return after all, as a by-product of automation. We are already learning to design better type in an effort to make it legible for machines; perhaps we shall have to mind our style more carefully if we know that at the other end a computer will have to make sense of it, not some long-suffering editor.

Programmers are already facing this problem and they never cease to tell us what fools computers really are: the only languages they understand consist of clear, simple symbols with no faults in the logic, no ambiguities of wording.

So, perhaps there is still some hope for that lucid scientific prose style; only, the way things look now, it will have to be confined to two words: zero and one.

Stainless steel for gas-liquor transport

A STAINLESS-STEEL road tanker which has already given three times the normal life of a mild-steel tanker, and is still going strong, is being used by the South Eastern Gas Board to transport concentrated gas liquor from their various gas works to the central chemical works. This is a notable experiment, for in the past mild steel has been predominantly used for the construction of such tankers. It is generally accepted that mild-steel tankers in contact with concentrated gas liquor will suffer general corrosive attack and are unlikely to give more than 12 months' safe service.

The 18/8 Ti-stabilised stainless-steel tanker has carried at least 7½ million gal. of such liquor, of which a typical chemical analysis is: 21% ammonia, 20% carbon dioxide, 3% hydrogen sulphide, and traces of cyanide compounds, the balance being water. The *p*H value is greater than 8. Investigations indicated that the main source of corrosion of mild steel by concentrated gas liquor are the cyanide compounds and, to a lesser extent, the sulphides.

A co-operative examination of the stainless-steel tanker was undertaken by the stainless-steel suppliers, Firth-Vickers Stainless Steel Ltd., and the road tanker manufacturers, W. P. Butterfield Ltd., in conjunction with the hauliers, E. H. Jones Ltd. The dished ends were found to be completely unaffected, there being no evidence whatsoever of any corrosion. This was very clearly confirmed by the fact that the grinding marks produced in cleaning up the welds joining the dished ends to the main body were as bright and clean as the day the operation was carried out. The majority of the tenacious deposits both on the dished ends and on the main body were removed with a paste made up of water and one of the mildly abrasive household cleaners, but close and thorough examination of the surface underneath showed it to be in perfect condition and to have suffered no harmful effects whatsoever.

On one of the bottom sheets, about 42 in. from the top of the tank, an area about 10 in. × 2½ in. of very fine shallow pitting was found. However, the circumstances surrounding this pitting, plus the fact that it occurs almost directly below the top manhole, suggest that it is due to some corrosive substance having accidentally fallen through the open manhole on to the bottom of the tanker. There is, moreover, no evidence that these pits are in any way harmful to the structure.

It is significant that no corrosion has occurred under the shielding effects of tenacious dried-on deposits from the gas liquor. The heat-affected zones adjacent to welds were also close examined but here, again, no corrosion or deterioration could be found.

The initial cost of a stainless-steel road tanker is a little more than twice that of a mild-steel one but the considerable increase in trouble-free life is well worth studying for its economical advantages.

Wooden fans

IN our July issue (page 236) we referred to attempts that are being made to revive wood as a material of construction for applications where it is at present unsuitable, by modifying it chemically. One field in which wood is unobtrusively holding its own without any need for such treatment is that of industrial fans. In many arduous conditions, including acid or other corrosive fumes, fans and impellers of laminated timber construction are giving long and trouble-free service.

The Airscrew Co. & Jicwood Ltd. claim to be the only company in the world making wooden impellers in large quantities for use in cooling towers. The timber is specially selected white seraya, from North Borneo, which is sawn into boards 1 1/16 in. thick, these being planed on the edges and edge-glued with *Aerodux* 185, a resorcinol-formaldehyde formulation, to form boards of the required width. The ensuing processes of taking profiles from the boards and cutting the laminate to accurate pitch and aerofoil section involve considerable skill. The shaping of the blades is sometimes done by hand and sometimes on a machine. When shaping is complete the whole surface of the impeller is made impervious to moisture by the application of a cellulose nitrate film, and the surface is brought to a fine finish by scraping with a sharp metal edge. The leading edge of the impeller is generally protected by the attachment of a stainless-steel strip or by the application of a neoprene paint.

In addition to two-bladed impellers a variety of four-bladed and other fans are made. They have a variety of uses; many are used in self-contained units for providing a stream of cool air to operatives subjected to radiant heat in foundries, furnace shops and similar locations. Fans with diameters of 15, 18 and 24 in. are available, capable of moving 3,000, 5,000 and 11,500 cu.ft./min. of air.

TOWER PACKINGS

Tower packings play an important part in distillation and absorption processes, but information on them is scattered. In the following pages we bring together the salient features of the main types.

How Random is Random Packing?

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It is important to know how the disposition of the packings in a random-packed tower affects the distribution of the liquid and, particularly, what contribution it makes towards the undesirable 'wall effect.' This article discusses investigations, using photography and mathematical methods, which throw light on this problem.

TOWER packings may be broadly divided into those which form a regular structure and those which are dumped into the tower in a random manner. Random packing may also be sub-divided from a cost point of view into those packing pieces which can be made fairly simply by extrusion, that is the various types of ring packing, and those needing more complicated production techniques, for example, saddle-type packings and Pall rings.

The first ring packing designed to be used in a random manner was that invented in Germany by Raschig.[1] Since then several modifications to the Raschig ring have been produced, including Lessing rings, cross-partition rings and spiral-type rings,[2] all of them retaining the Raschig ring characteristic of length = outside diameter.

The advantages of random ring packing claimed by Raschig were, firstly, that it facilitated the complete filling of the tower and, secondly, that the liquid flowing down from the top, even when admitted at only one point, soon distributed itself over the entire tower cross-section. This means that a far less complicated liquid distribution system may be used with random packing than with stacked packing, due to the ability of random packing to spread the liquid.

This advantage of liquid spread is, however, confined to the bulk of the packing. When the liquid reaches the walls there is little tendency for it to return towards the centre of the tower and the well-known wall effect of a much greater flow of liquid per unit area at the wall is produced. This type of maldistribution has been observed by Baker *et al.*[3]

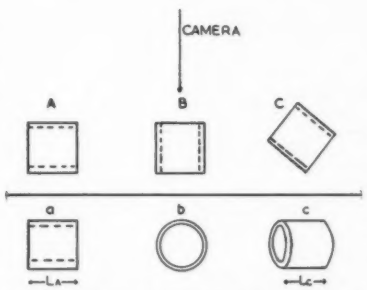

Fig. 1. Diagram showing how apparent length differs from actual length when a bed of Raschig rings is photographed from above.

When the ratio of liquid rate to gas rate is different at different parts of a tower horizontal section, operating lines of different slopes are produced, and pinch zones or zones of small mass transfer may occur. Maldistribution produces the worst results for high ratios of mL/G, the ratio of the slopes of the equilibrium and operating lines. This adverse effect of maldistribution on mass transfer is explained by Mullin.[4]

Thus, although the ability of random packing to give a component horizontal to the direction in which the trickling liquid moves is an advantage in that it requires a simpler initial distribution apparatus, it is a disadvantage in that it transports liquid to the column walls.

Kirschbaum[5] attributes the wall effect to the different positioning of the packing next to a plane wall. He suggests that in a packed distillation column this causes liquid maldistribution at high reflux rates, while at low reflux rates the maldistribution is due to vapour flow favouring the wall where the voidage is greater. He has shown that a gain in efficiency can be obtained by using a column with corrugated walls.

Most work on random - packed columns has been concerned with the behaviour of the fluids flowing through the tower. Investigations have been made into liquid holdup, gas pressure drop, flooding rates and mass transfer efficiency. Little work has been done on the packing. Robley *et al.*[6] have investigated voidage in a tower packed randomly with Raschig rings and found a slight increase of voidage near the wall. The maximum voidage occurred at one ring radius from the wall and was about 1.25 the voidage in the bulk of the packing.

The present work is concerned with the determination of the angle of inclination of the rings in the bulk of the packing, which influences the spread of liquid up to the wall.

Experimental

The method used was to photograph the surface layer of a bed of rings from directly above and to calculate the angle to the horizontal of each ring from a comparison of its apparent length with its actual length.

The rings used were ¼-in. ceramic

Raschig rings, which were dropped through water into a metal box 10 in. wide × 10 in. long × 5 in. deep. The photographs were taken with a plate camera fixed 2 ft. above the centre of the box. The photographs were enlarged so that the size of each ring appeared to be about $\frac{3}{4}$ in.

The actual length of a ring was obtained for each photograph from those rings which showed only a side, or only an end, that is from those rings directly in line with the camera. Referring to Fig. 1:

Ring A appears as a.

Ring B appears as b.

Ring C appears as c.

The apparent length of A is l_a and is the actual length for the rings in the photograph. The angle to the horizontal of C is given by $cos\theta_c = \frac{l_c}{l_a}$. Thus for B, $cos\theta_B = \frac{l_b}{l_a} = 0$ and $\theta_B = 90°$.

The angle to the horizontal, estimated in this manner, of those rings not directly underneath the camera had to be corrected, the size of the correction depending on angle α (see Fig. 2). The correction varied between 0 and 14°. The apparent length of each of the rings in each photograph was measured and θ was calculated for each ring by $\frac{l_c}{l_a}$. Diagrams were constructed similar to Figs. 3 and 4, neglecting the perspective effect. These diagrams were then corrected by an overall correction factor based on the proportion of the total number of rings at different angles α.

Presentation of results

The results are presented in Figs. 3 and 4. The ordinate is the percentage of the total number of rings in a photograph which lie at certain angles to the horizontal, given by the abscissa. Thus Fig. 4 shows that 8.9% of the rings lay with their axes inclined between 0 and 10° to the horizontal, while 17.5% were inclined at between 40 and 50°.

Fig. 3 shows results for three separate quarters of a photograph showing the surface layer of a bed of $\frac{1}{4}$-in. Raschig rings $\frac{1}{2}$ in. deep. This figure indicates the accuracy of the method. It should be noted that in this form of presentation the accuracy will increase with the number of rings considered.

Fig. 4 is based on results for 1,032 rings at different bed depths of $\frac{1}{2}$, $1\frac{1}{2}$ and 2 in.

Discussion of results

From Fig. 3 it can be seen that great accuracy cannot be claimed for these results, but Figs. 3 and 4 definitely indicate that the rings tend to lie on their sides rather than on their ends. In any bed of rings, those rings which tend to lie on their sides will be the distributing rings and spread the liquid about the tower, while those rings lying on their ends will provide free area for gas or vapour flow. By arbitrarily choosing an angle of 45° to distinguish mainly distributing rings from mainly free area rings, Figs. 3 and 4 show there are more 'distributing' rings in a random packing than 'free area' rings.

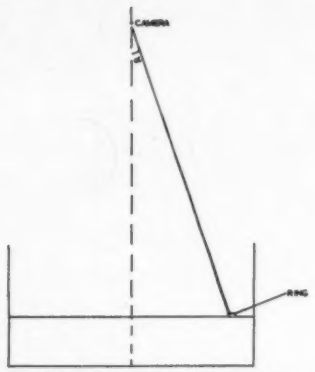

Fig. 2. Angle of correction for Raschig rings not immediately under camera.

Fig. 3, for a layer only $\frac{1}{2}$ in deep, shows that even when the ring bed is resting on a flat surface this pattern of angles of inclination of rings develops at least within the second or third layer of rings

Rings lying on their sides will be less easily wetted inside than rings lying on their ends. Greenaway[7] measured the proportion of the total flow that flows inside the rings and found that this was only 29% for $\frac{1}{2}$-in. rings, dropping to 12% for $1\frac{1}{4}$-in. rings. This is in qualitative agreement with the results reported here.

Wall effect

Of 250 rings touching the wall:

60% had their sides lying flush against the wall.

15% had their ends lying flush against the wall.

14% tended to take liquid away from the wall.

11% tended to take liquid towards the wall.

That is, in the area up to one ring dia. from the wall, 75% of the rings have no distribution effect to or from the wall, and liquid entering this area will tend to stay next to the wall.

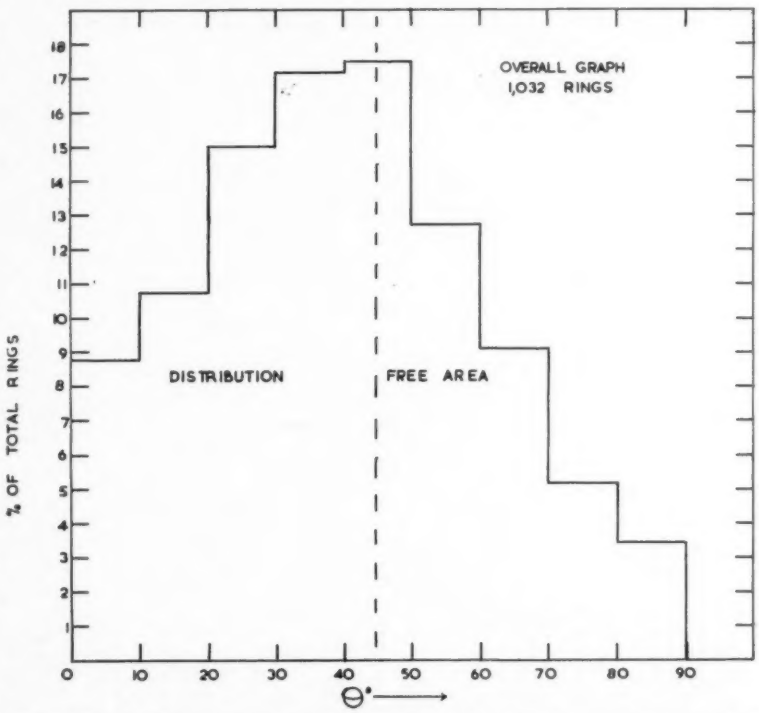

Fig. 3. Graphical representation of results obtained from photographing a bed of Raschig rings.

Effect of modifications to the Raschig ring

Several modifications to the Raschig ring now in use are intended to be used dumped in a random manner: Lessing rings, cross-partition rings and Pall rings.[2]

Assuming that rings with the same ratio of length to diameter as the Raschig ring will arrange themselves in a similar manner when randomly packed, only the Pall ring is likely to be more wetted on the inside because of the openings in its sides. It is also claimed for this ring that maldistribution is less.[8]

Stacked packing

Many recent developments in tower packing consist of a regular (instead of a random) structure for gas-liquid contact. *Spraypak*, Stedman, *Dowpac* and *Multifil* packings are examples of packings designed to be used on an industrial scale, which provide a regular but elaborate structure.

Ceramic packings are limited to simpler shapes and smaller unit sizes and are most easily made by extrusion. For these reasons a regular ceramic packing is stacked and presents vertical surfaces only for liquid flow. The advantages of such a stacked packing are that it is easier for all its surface to be wetted, and the absence of cross liquid flow will prevent wall maldistribution. However, the absence of cross liquid flow also means that the initial distribution of liquid, once set up, will be maintained. Thus such a stacked packing is only as good as its distribution system.

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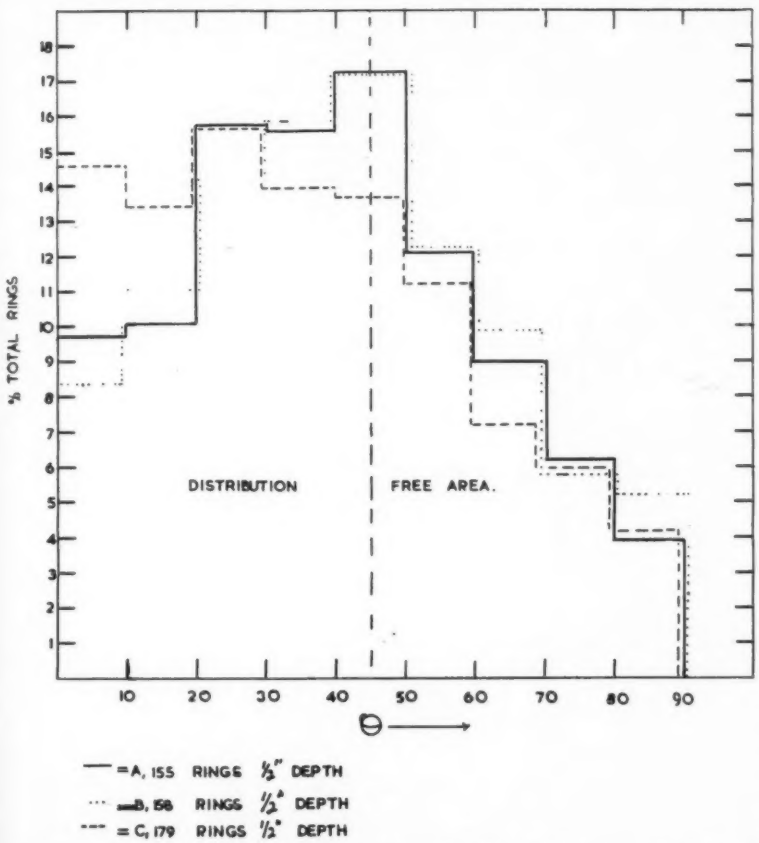
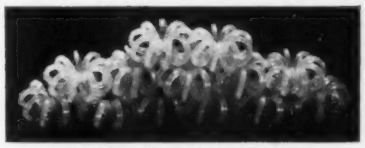


Fig. 4. Diagram showing proportion of Raschig rings at various angles to the horizontal in a random-packed bed.

Rosette tower packing

In the *Tellerette* packing, advantage is taken of the low weight and corrosion-resistant properties of polythene, and the unusual shape of this packing, which may be described as a helical torus—or, more simply, as a rosette composed of a number of turns of polythene strip—is aimed at creating a multiplicity of interlocking contact points which result in high interstitial



Polythene 'rosette' packings.

holdup independent of flow conditions. The packing is finding a number of applications in fume scrubbing and gas processing. It has been employed, for instance, for the absorption of such gases as CO_2, CO, H_2S, NH_3 and dilute Cl_2, while fume-scrubbing applications include the absorption of the oxides of nitrogen produced in metal-treating operations, the absorption of fluoride emissions produced in superphosphate manufacture, and the absorption of other gases in air pollution control.

The Harshaw Chemical Co., who produce *Tellerette* packings, give the following comparison of the physical properties of 1-in. polythene *Tellerettes* with those of 1-in. ceramic Raschig rings and 1-in. ceramic Berl saddles:

	Tellerette	*Raschig*	*Berl*
Free vol., % ..	83	66	69
Surface, sq.ft./cu.ft.	76	58	76
Interstitial holdup points/cu.ft.	37,000	10,800	17,500
Wt., lb./cu.ft. ..	10	48	45
No. of units/cu.ft.	1,125	1,330	2,200

It is claimed that the filament construction of *Tellerette* packing does not lend itself to clogging and that deposits produced in the absorption of many industrial air pollutants readily flush away. It is also claimed that the efficiency of the packing is such that tower height can be reduced, with subsequent savings in cost. The low weight of the packing permits the use of simple wire-mesh support plates.

For most applications the packing can be used up to a temperature of about 150°F., while for installations where considerable chemical resistance and higher service temperatures are required, a packing is available which is fabricated from linear or high-density polythene and which may be used up to 225°F., depending on the chemical environment.

Selection of Tower Packings and Accessories

By D. G. Randall, B.Sc.(Eng.), M.I.Chem.E., A.F.Inst.Pet.
(Technical Director, The Hydronyl Syndicate Ltd.)

There are many factors to be considered before deciding what type of tower packings is best for a particular duty; what size the packings should be, and whether they should be metal or ceramic. This article discusses these problems and includes some points about the design of packed towers.

TOWER packings represent the oldest means of securing mass transfer and primitive types, such as broken coke and quartz, were in common use long before the turn of the century. The first major advance was the use of plain cylindrical rings by Raschig about 1914. This was shortly followed by Dr. R. Lessing's invention of the well-known ring packing which bears his name. In 1931 the Berl saddle appeared, but, although having excellent characteristics, this packing enjoyed only a limited use because of its high cost of production.

A survey at the end of World War 2 might have shown that the development of tower packings had apparently reached its limit. Although a large number of other shapes and types had been mooted, only the three previously mentioned had enjoyed wide use. It was indeed fashionable in some quarters to regard tower packings as outmoded, except for certain specialised purposes.

During the past decade, however, a remarkable phase of development has taken place. On the one hand, the plain ring has been ' turned outside in ' to yield the Pall ring, with its permeable wall and its well-disposed and highly wettable surface. On the other hand, the saddle packing has been regenerated in the form of *Intalox*, which is at once cheaper to produce and more efficient and robust than the Berl saddle. *Intalox* saddles are dealt with more fully in another article in this issue.

Wire-mesh packings have also undergone a phase of development. Stedman packings and Dixon rings had been developed during or just before the last war, but their high cost and certain inherent disadvantages had limited their use mainly to small columns. However, in recent years entirely new types of packing, represented by the Goodloe packing in the U.S.A. and *Multifil* packing in the U.K., have been developed. These are knitted multiple-filament materials, which are crimped and rolled in a special manner to suit the diameter of the column. They are characterised by very high efficiency, excellent throughput and low pressure-drop characteristics. Also, the first cost is relatively moderate. On the other hand, Borad rings represent a marked advance over Dixon rings in that they show high efficiency without the need for pre-flooding. Yet a further development is the knitted single-filament packing, which has proved a highly efficient demisting material.

Spraypak is another development which is a borderline case. In one of its forms expanded metal elements with triangular pressings are stacked in the correct formation without being fixed together and could therefore be regarded as a stacked packing. However, it cannot be regarded as a typical tower packing and will not be dealt with further here, except to say that it is an economical metal packing with a very high throughput. The same remarks apply to grid packings, in which interest has recently revived.

Apart from the development of new tower packings, the design of packed towers and the concomitant accessories which are so essential for their successful use have undergone a similar transformation, which is referred to in later sections of this article.

Versatility

It can truly be said today that tower packings are showing a versatility and vitality which enables them to compete, often on more than equal terms, with the best and most modern tray devices. Tower packings lend themselves very readily to the needs of the typical chemical works, where operations are diversified and constantly changing. If column shells of several different sizes are available, these can be packed with different sizes and types of packing to meet widely different conditions and throughputs. A packed column can easily be increased in height or if this is undesirable, a smaller size or more efficient type of packing can be employed. It is, however, important that the available choice of packings should be deployed intelligently. It has been the misfortune of tower packings in the past that they have lent themselves too readily to those amateurs who have proceeded on a ' do-it-yourself ' basis and with too little knowledge and less insight, whereas the competing devices have been the prerogative of plant manufacturers and specialists.

Fortunately, with increasing numbers of trained chemical engineers coming into circulation, and with increasing experience, this state of affairs is receding. It is now generally realised that the design of a packed column merits just as much care and detailed attention as the design of a tray column.

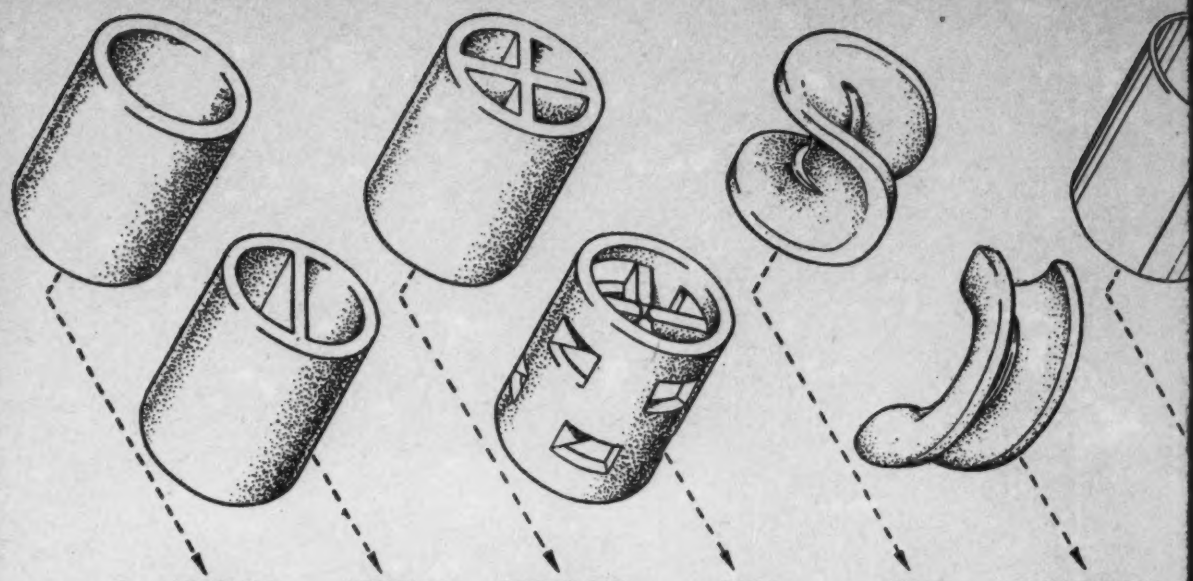
It is also true to say that some large and badly designed packed towers have been put up in the past and this has led to the popular misconception that packings are not suitable for large towers. In fact, there are many efficient packed towers now giving good service; they include some of the largest towers of any kind in the world.

Criteria for selection

The chart which appears opposite gives a general guide to the most commonly used tower packings, with indications of their salient characteristics, applications and materials of construction. For more precise details, the makers' literature should be consulted.

It should be particularly emphasised that tower packings cannot be compared with one another simply on the basis of voidage or specific surface. These characteristics are only part of the story. Other factors, which cannot be expressed so simply, concern

MAIN TYPES OF



TYPE OF PACKING	RASCHIG RING		LESSING RING		CROSS PARTITION RING	PALL RING	BERL SADDLE	INTALOX SADDLE
	CERAMIC TYPES							
USUAL SIZE RANGE[1] (in.)	¼—4		¼—4		3 & 4	1—4	¼—1½	½—2
MODE OF PACKING	To 2 in. Random	3 & 4 in. Stacked	To 2 in. Random	3 in. Stacked	Stacked	Random	Random	Random
PACKING COEFFICIENT[2]	0.78	1.00	0.75	1.00	1.00	0.79	1.24	1.49 to 1.23
SURFACE FACTOR[3]	1.00	1.00	1.17	1.23	1.42	1.25	1.32	1.69 to 1.24
VOIDAGE RANGE[4] (%)	71—77	61	64—72	58	56—59	72—76	60—74	75—79
REMARKS	Lowest cost, lowest performance. Stacked rings give lower pressure drop.		Greater strength and surface. Larger sizes used as base support courses (stacked). Slightly higher pressure drop.		Very robust with good surface area but poor voidage —widely used for sulphuric and nitric acid plants, etc. See also note (5) below.	Very good throughput and pressure drop characteristics — efficiency higher than Raschig rings. Especially advantageous in larger sizes.	Good thoroughput, pressure drop and efficiency. Mainly used in smaller sizes.	Slight all-round improvement on Berl saddles, also cheaper and more robust. Especially advantageous in smaller sizes.

CHEMICAL RESISTANCE

Ceramics. The most commonly used materials are porcelain and stoneware, which have similar chemical resistance and can be employed for most chemicals except caustic alkalis and hydrogen fluoride. The smaller sizes are usually made from porcelain which is purer and non-porous. Chemical stoneware is cheaper and satisfactory for most large-scale applications, including the hot concentrated acids.

MECHANICAL PROPERTIES

Glass occasionally used for smallest sizes.

Carbon. Thicker walled, more expensive. Used against HF and alkalis.

All ceramic types are liable to breakage by impact.

NOTES

1. Raschig rings are available in the following sizes (length = diam.): ¼, ⅜, ½, ¾, 1, 1½, 2, 3, 4 and 6 in.

2. Packing coefficient (*P*) enables approx. No./cu.ft. (*N*) for any size of packing (*d*, inches) to be calculated from the formula:

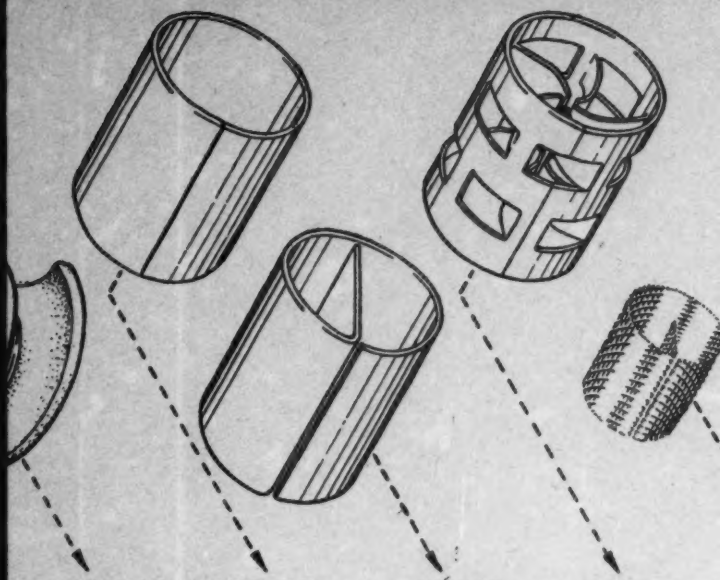
$$N = (1{,}728 \times P) \div d^3$$

3. Surface factor is based on ceramic Raschig rings for which surfaces in sq.ft./cu.ft. are as follows: (random) ½ in., 112; 1 in., 58; 2 in., 29; (stacked, square pitch) 3 in., 25; 4 in., 20. (Surface inversely proportional to size.) Hence approx. surface for any packing can be quickly calculated. Surface as a criterion of efficiency is subject to effectiveness of wetting.

4. The voidage (*V*) may be used to calculate … of the material is known, using the formula: … 150 lb./cu.ft. approx. and for steels, etc., 500 … drop and throughput characteristics when … form of the packing).

5. An alternative type with three helical sp… be appreciably more efficient and is more e…

S OF TOWER PACKINGS



INTALOX SADDLE	RASCHIG RING	LESSING RING	PALL RING
	METAL TYPES		
½—2	½—2	½—3	½—2
Random	Random	Random	Random
1.49 to 1.23	0.80	0.77	0.81
1.69 to 1.24	1.10	1.35	1.13
75—79	91—94	91—94	93—95
Slight all-round improvement on Berl saddles, also cheaper and more robust. Especially advantageous in smaller sizes.	Better voidage than ceramic type. Used for caustic alkalis; unaffected by thermal and mechanical shock. Will withstand removal for cleaning.	Similar to Raschig but with extra surface area. Only slightly more expensive because of ease of production.	Similar to ceramic type but even better throughput and pressure drop due to larger slot area and voidage. Unbreakable. Good for high vacuum.

cal resistance and
sually made from
cale applications,

Metal types are not liable to breakage by impact or thermal shock and have generally thinner walls and higher voidage. Used where conditions of handling, cleaning or surging are severe; also for vacuum work.

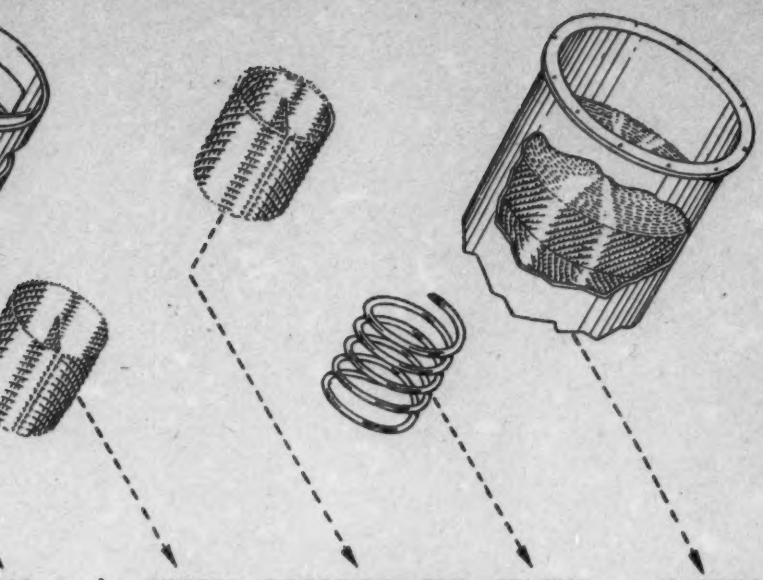
Mild steel gives moderate service life for many alkali applications. More expensive than stoneware.

Stainless steel more resistant and expensive. Aluminium, copper, nickel and *Monel* sometimes used.

) may be used to calculate the approx. bulk density (W) if the true density (D) known, using the formula: $W = (100 - V)D$. For the common ceramics $D =$ ox. and for steels, etc., 500 lb./cu.ft. approx. (Voidage is only a criterion of pressure hput characteristics when considered in conjunction with surface area and the ng).

type with three helical spokes is the triple spiral, which is not now believed to ore efficient and is more expensive.

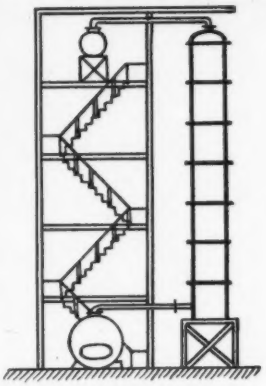
C



ALL NG	DIXON RING	BORAD DOUBLE GAUZE RING	FENSKE HELICE	MULTIFIL ROLLS
	WIRE AND MESH TYPES			
—2	$\frac{1}{10}$, $\frac{1}{8}$, $\frac{1}{4}$	$\frac{1}{8}$, $\frac{1}{4}$	$\frac{1}{8}$, $\frac{1}{4}$	Rolled to any diam.
ndom	Random	Random	Random	Single stacked
0.81	0.75	0.75		
1.13				600 sq.ft./cu.ft.
—95	93—95	90—93		94—95
to ceramic t even bet- roughput ssure drop larger slot d voidage. eakable. for high	High cost confines these mainly to laboratory columns in which H.E.T.P.s down to about 1 in. can be realised. Must be pre-flooded.	Superior to Dixon rings; even lower H.E.T.P.s obtainable; pre-flooding not required.	Cost and efficiency lower than Dixon and Borad rings. Very low pressure drop.	H.E.T.P. similar to $\frac{1}{4}$-in. Dixon rings (pre-flooded). Much lower cost permits use in small commercial columns; especially suitable for high vacuum. Pre-flooding not required.
mpact or valls and handling, m work. ny alkali uminium,	**Metal wire.** Because of the fineness of wire employed absolute corrosion resistance is essential for any given application. Stainless steel (F.M.B. or F.S.L.), nickel, *Monel*, phosphor bronze or copper (in order of cost) may be used.			

CHEMICAL & PROCESS ENGINEERING
SEPTEMBER 1959

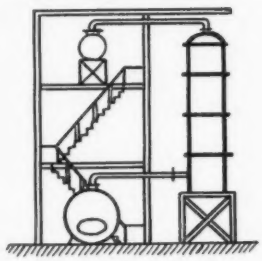
Chart produced with the co-operation of The Hydronyl Syndicate Ltd.



DESIGN No. 1
(25 theoretical plates)

Column:
50 ft. packed height (2-in. Raschig rings)
60 ft. overall height
2 ft. 6 in. diam. (four redistributors)

Capital costs:	£
Column shell	2,000
Packing	180
Structure	1,500
Other items	2,500
Total	6,180



DESIGN No. 2
(25 theoretical plates)

Column:
20 ft. packed height (1-in. *Intalox*)
27 ft. overall height
2 ft. 7½ in. diam. (one redistributor)

Capital costs:	£
Column shell	1,100
Packing	240
Structure	800
Other items	2,500
Total	4,640

Fig. 1. This illustration shows how overall cost of a packed column can become unnecessarily inflated through undue emphasis being placed on cost per cu. ft. of packing. The two hypothetical designs illustrated are for the same duty.

the degree of obstruction to vapour on the one hand and the effectiveness of wetting on the other.

Furthermore, the comparison of packings of the same nominal size can be misleading, as the differences in packing densities between different types can be quite wide. The effect of material of construction, as between thick-walled types and thin-walled types, may also be considerable, especially in the smaller sizes. For this reason ceramic and metal packings have been classified separately.

Design of packed towers

Two cardinal principles of packed tower design cannot be too strongly emphasised:

(*a*) The tower must be rated so as to be properly loaded as regards both liquid and vapour in the normal working range. Under-loading is a more insidious cause of failure of packed towers than over-loading. The latter condition usually becomes obvious and is therefore rectified, whereas serious under-loading will merely give poor performance without obvious symptoms which cry for attention.

(*b*) Correct design of the accessories and correct installation are just as important as correct choice of packing. A support grid which has too little free area or is prone to blockage, either by the packing itself or by broken pieces, may cause virtual failure of the column. Breakage of the packing may result from careless dumping or from other causes, such as bad design or omission of hold-down plates. Poor performance may be caused by incorrectly designed feed distributors or the omission of liquid distribution correctors at suitable intervals.

In the rectifying sections of distillation columns the mass rate of the liquid is never more than that of the vapour, therefore to ensure satisfactory wetting it is important to use an efficient type of packing which will also ensure that the cross-section of the tower is kept to a minimum; hence the wetting rate per sq. ft. will be at a maximum. This problem is further accentuated by vacuum, since for a given mass flow-rate a larger cross-section is called for.

In absorption the liquid/gas ratio may vary widely. In cases of very low liquid rate, as in the scrubbing of a small concentration of a constituent from air, continuous circulation by air lift or pump may be employed, sometimes with several towers in cascade. This latter method may be employed where there is also chemical reaction involving a time lag.

Literature of tower packings

It is obviously impossible to cover here all the principles of packed tower design and the reader is referred to the sections on absorption and distillation in reference [1] and for the design of absorption columns to reference [2]. Reference [3] is the most comprehensive manual devoted entirely to tower packings and has an extensive list of references at the back. There are, of course, many other books having sections dealing with the subject which cannot be listed here.

Graphical methods and nomograms are often useful for a quick appraisal. References [4] and [5] give methods for the design of packed towers, covering Raschig rings and *Intalox*, but suitable factors would have to be applied for other packings. These should be useful for quick trial-and-error assessments of the effect of using different sizes of packings, etc., but the parameters finally selected should be carefully checked by independent calculation. References [6] and [7] review the literature, 1954-59. The designer is recommended to consult the tower packing specialists, particularly at the outset of any new project.

Choice of material

It must be decided at the outset whether a ceramic or a metal packing is to be used. This choice usually turns on chemical and strictly practical considerations. Ceramic packings are generally cheaper than metal packings, but in some cases are liable to breakage. Ceramic packings are resistant to most chemicals commonly encountered, with the notable exception of strong caustic alkalis and fluorides. If the packings will have to be removed at intervals for cleaning, it may be better to employ the metal type if corrosion considerations permit, since the packing may be more readily cleaned and breakage will not arise during this operation. On the other hand, if fouling is particularly severe and irremovable, it may be expedient to use cheap stoneware Raschig rings, which can be discarded periodically and replaced by new ones without excessive cost.

Thin-walled metal packings have a higher voidage and hence higher throughput (alternatively, lower pressure drop) than the thick-walled ceramic types, but not necessarily higher efficiency; this higher voidage may, for instance, be all-important for high vacuum work, where low pressure drop is desired.

Large continuous petroleum refinery and chemical plants must operate with a high standard of re-

liability and this factor outweighs marginal economies in the first cost of equipment. Thus there is a tendency to use stainless steel for packings in such cases rather than ceramic or mild steel. On the other hand, ceramic packings are widely used by the chemical industry and often give a lifetime of service when design, conditions and handling have all been given proper attention.

Carbon is usually reserved for those cases where neither ceramic nor metal is suitable; for instance, mixtures of caustic alkali and other corrosive agents or mixtures containing hydrofluoric acid.

Type and size of packings

Even now packings are sometimes chosen after comparison of the price per cu. ft. for different types. This usually leads to the choice of the least efficient type of packing, so that a relatively large volume of packing is necessary, with consequent all-round increases in the column structure and accessories. The result is that the overall cost of the plant—and even of the packing itself—is unnecessarily inflated. In practice the cost of the packing is usually a small part of the total cost of the plant and if an efficient packing is chosen this can reduce the indirect costs to an extent which often far outweighs the total cost of the packing.

This is illustrated by the two notional cases shown in Fig. 1 for alternative designs for a stainless-steel batch distillation plant. In each case the duty is the same and it is clear that the increased cost of the more efficient packing in design No. 2 is greatly outweighed by the indirect savings. This is, of course, a particular case not necessarily valid in different circumstances. For instance, if the column was of mild steel or did not require a structure, 2-in. ceramic Pall rings might be preferred, to give a column of intermediate height and smaller diameter in which the actual cost of the packing alone is less than for 2-in. Raschig rings. Again, for high-vacuum work it might be desirable to use stainless-steel Pall rings, despite their much greater cost.

The correct approach is, firstly, to consider the total cost of the different volumes of packings of different types to perform the required duty. Secondly, these different types of packings will call for columns of different diameters and heights, and the extent to which these differing dimensions will affect the other plant costs should then be considered.

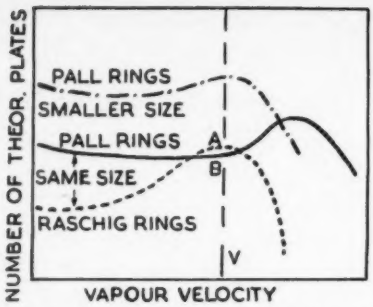


Fig. 2. How efficiency can be affected when using different packings at same throughput.

The choice of size and choice of type of packing are inseparable and must be considered together. Some packings are only made in a limited size range and others may be at their best in one or two sizes. Very small porcelain rings tend to have indifferent performance because the hole is too small to be effectively irrigated and voidage is poor. Very small Berl saddles may be better, provided they are thin and well shaped, otherwise they are little better than a granular material. It is preferable, if possible, to use a thin-walled metal or wire-mesh packing for small high-efficiency columns.

In essence, the size of packing determines the height of the column, and this is often the most important parameter. Excess height is usually much more expensive than extra diameter, as shown by Fig. 1. In such cases it is desirable, therefore, to use a reasonably small size of packing, even though this may involve a greater overall cost of packing.

For the majority of full-scale random packing applications a nominal size of packing in the range 1 to 2 in. is recommended. As the size is further reduced the cost per cu. ft. tends to rise steeply with relatively smaller gains in efficiency, especially in the ceramic types. As the size is increased beyond 2 in., on the other hand, the cost tends to flatten out, while efficiency continues to decline.

The choice of size is subject to the following further important considerations:

(1) The nominal size of packing should never be greater than one-eighth of the tower diameter and preferably one-sixteenth or less.

(2) There is no object in using a small size of packing if this provides more surface than can be effectively wetted (see reference [8] *re* M.E.L.R.).

(3) If fouling is expected, or if very low pressure drop is required, it is better to use a relatively large size of packing. In such cases a stacked packing is usually preferable.

Repacking existing towers

It is often possible to repack an existing tower to improve performance without alteration to the shell or external arrangements, thus saving both money and time off-stream. The existing tower may have bubble trays or plain rings and the correct choice of a high-efficiency packing will usually enable either the throughput capacity (or pressure drop) or, alternatively, fractionating (or absorption) efficiency to be improved.

However, it is important to be quite clear as to the particular objective to be achieved and also to know the characteristics of the various packings. Take the case of a well-designed column packed with Raschig rings and operating at a throughput (point *A* in Fig. 2) corresponding to optimum efficiency. It is desired to increase efficiency, but not throughput (V). In the hope of achieving this Pall rings of the same size are substituted. It will be seen from Fig. 2 that they will be operating at point *B*, *i.e.* at a slightly lower efficiency than before, because the Pall rings with their much greater throughput potential are relatively under-loaded. If the throughput can be increased, then the efficiency will rise also. This is, of course, an extreme case, but serves to illustrate the point.

Pressure drop will naturally have been much reduced by substituting Pall rings and if this had been the desired end this course might have been justified.

The correct solution would have been to use a smaller size of Pall ring to increase efficiency at the same throughput (shown chain-dotted on diagram).

Choice of accessories

An otherwise well-designed packed tower may fail completely because of insufficient attention to the accessories or faulty installation. For instance, a support grid having 50% free area is installed in a column; obstruction by the packing may reduce this by half and broken pieces arising from careless handling may still further reduce the free area.

Ideally a support grid should have 75% free area or more, although this is not always possible in practice. In difficult cases conditions can be mitigated by using one or two stacked courses of a larger size of Lessing ring before putting in the main packing.

A grid comprised primarily of parallel strips on edge gives the best combination of high free area and strength.

The geometry of the packing in relation to the grid should be given common-sense consideration. For instance, rectangular holes in a grid should not be of a size which will just cradle a ring lying on its side, nor of a size which will just accept the end of an *Intalox* saddle. Support plates with round holes have poor free area.

The corollary of a good packing support is a good hold-down plate. The object of this is to prevent movement in the upper layers of the bed which will cause attrition and in the extreme case to prevent rings being blown through the vapour outlet. This often happens unexpectedly, in columns not normally heavily loaded, due to sudden surges, which are especially likely to occur in pressure or vacuum columns.

Fixed grids have the disadvantage that the packing nearly always settles a little in service, so that the plate is no longer effective in preventing attrition. Surges may cause rings to be thrown against the grid, which makes matters worse.

An effective type of hold-down plate has been developed by the U.S. Stoneware Co. This is of the free-gravity type and is designed to apply just sufficient pressure to prevent movement of the rings; this will be effective however much the packing settles. At the same time, the free area of the plate is such as not to interfere with the performance of the column.

Efficient feed distribution is most important for the columns of larger diameter, though in the smallest diameters a single central point may suffice. It is important that the distribution should remain uniform for the appropriate range of variation of feed rate. The distributor points should not be prone to blockage nor cause splash.

Redistribution of liquid at intervals is desirable for most columns. Ideally this should be at intervals of three to five diameters, the lower ratio being for ratios of tower diameter to packing size of about 8 : 1. Where this ratio is very large, or where *Intalox* or Pall rings are employed, the need for redistribution is reduced. It is sometimes, in any case, expedient to reduce or even omit the redistributors because of constructional economics and to increase the height of packing instead.

Slant or ' wall scraper ' rings are sometimes used as a simple distribution corrector. However, these cannot be recommended; if they are wide enough to throw the liquid in to an effective distance from the walls, they will impede the flow of vapour near the walls for a significant height of packing above. On the other hand, if they are narrow they will not correct the liquid starvation in the central area and the liquid will quickly find its way to the wall again.

A more effective variation, which is almost as simple and quite effective for small and medium-size columns, is a narrow annular trough at the wall with three or more inclined drain pipes to bring the liquid from the wall to a point near the centre.

For larger columns more complicated devices are available, such as the Schliebs - Kirschbaum circular tray with a large number of orifices at three different levels to allow for a considerable range of liquid rates.

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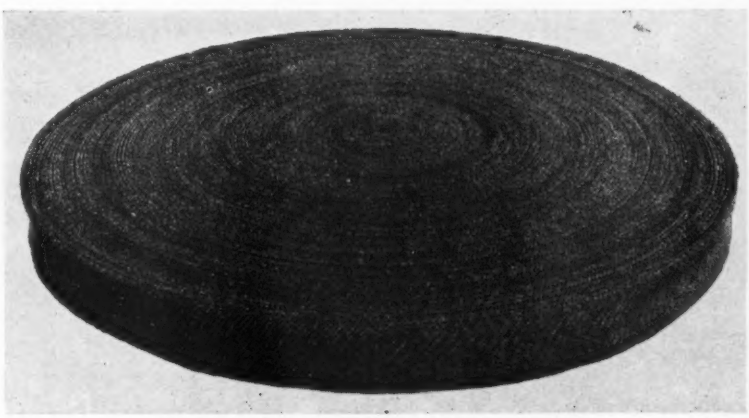
[8]H. R. C. Pratt, *Trans. Inst. Chem. Engrs.*, 1951, **29** (2), 195. ' Performance of Packed Columns '—wetting and minimum effective liquid rate. (See also adjacent paper by Williamson.)

Goodloe packing

The Goodloe packing is claimed to have a very low pressure drop, a low holdup, a capacity somewhat in excess of that of a conventional bubble tray and a contacting effectiveness approaching that of Stedman packing. It is normally made of wires of 0.0045 in. diam., 12 strands being knitted together to form a tube. The tube is then flattened to make a double-thickness ribbon about 6 in. wide which is crimped, the creases of the crimping being at an angle to the centreline of the ribbon. Two ribbons are then arranged in reversed relationship so that the creases cross each other and thereby determine the spacing of the adjacent ribbons. The two ribbons are rolled together until a cartridge is formed having enough layers to fit the column snugly.

Recently, Goodloe packing knitted of nylon monofilaments has been introduced for laboratory and commercial use. This nylon packing is intended for applications where contact with metals must be avoided and for cases where metals of suitable corrosion resistance would be more expensive.

The Goodloe packing takes its name from Mr. A. M. Goodloe of the Metal Textile Corporation, U.S.A., who devised its main feature. The packing was developed by the co-operative efforts of Metal Textile and the Packed Column Corporation. The latter company reports that it has so far supplied packing for 212 columns that range in diameter from 19 mm. to 67¾ in. and in height from 6 in. to 49 ft.



Goodloe packing cartridge 6¾ in. in diameter.

Performance Characteristics of 'Intalox' Saddles

By J. A. Field
(*The Hydronyl Syndicate Ltd.*)

This article discusses a tower packing of an improved saddle shape for which a number of advantages are claimed.

THE primary function of tower packings is to provide contact between (*a*) gases or vapours and (*b*) liquids. This contact must be obtained in such a manner that the resistance to gas and liquid flow is slight and a large area wetted with a flowing film of liquid is provided. Consideration of the wide variety of shapes of tower packings hitherto used by industry indicates that a saddle-shaped element is likely to fulfil these essential conditions.

A packing of this shape—the Berl saddle—has been used industrially with considerable success, mainly in the ½-in. to 1-in. size range. Although the transfer efficiency was higher and the pressure drop was lower than with earlier types of packing, the high cost of manufacture restricted its use, in the majority of cases, to units of laboratory and pilot-plant size.

The very regular shape of the Berl saddle was also a disadvantage, as it caused a significant amount of 'nesting' when the saddles were packed indiscriminately into a vessel; such nesting causes channelling of the gas and liquid flowing through the packing.

Advantages of 'Intalox'

The *Intalox* saddle was designed to overcome these disadvantages. The shape is such that adjacent elements do not blank off any significant portion of their surface and a high proportion of the available surface is accessible to the wetting liquid; no stagnant pools of liquid form and no bubbles of gas are trapped. In a bed of *Intalox* saddles (see Fig. 1) the voids are uniform and all surfaces are smoothly rounded; consequently gas passing through the bed is not subjected to violent changes of direction. This contributes to the remarkably low pressure drop experienced in industrial installations. Another factor is the free flow of liquid over the curved surfaces, which minimises liquid 'hold-up.'

Intalox saddles are made of a porcelain body fired to full vitrification, giving a dense product mechanically strong and completely resistant to attack by all acids except hydrofluoric. The absence of sharp corners and fragile projections means that mechanical breakage of the packing elements during transport and handling on site is reduced to a minimum.

Movement of the packing in a tower, due to vibration caused by fluctuations of pressure or of liquid and gas load, results in abrasion or breakage of the packing, so that the voids are gradually filled with fragments and the pressure drop through the bed is increased. The smooth surface of *Intalox* and the rigid bed that is formed reduce abrasion and ensure that the initially low pressure drop is maintained.

Fig. 1. Portion of a bed of 'Intalox' saddles.

Intalox saddles are available in nominal sizes of ½, ¾, 1, 1½ and 2 in. The nominal size is taken as one-third of the sum of the length, height and width of an element.

Operating performance

The merits of these saddles are demonstrated in lower operating costs and higher operating efficiency. Pressure drop is greatly reduced compared with older packings, as shown in Fig. 2. For that reason capital outlay on blowers and pumps is lower and power consumption is sharply curtailed.

The throughput of gas and liquid using *Intalox* saddles is far higher than with most other packings, without increase in the pressure drop. Consequently it is possible in many cases to increase the capacity of an existing tower up to 30% by changing the packing to *Intalox*. On the other hand, new columns may be designed with much smaller diameters than was previously possible.

To avoid flooding at the support grid it is good practice to place a few layers of the next larger size of saddle on the grid below the main packing. This permits the apertures in the grid to be made wider than the nominal size of the main packing without risk of any falling through the grid.

It has now been established that the most efficient operation of absorption columns is in the 'loading' range, working at gas and liquid rates much in excess of those once thought to be practicable or economic. The very high throughputs permissible with *Intalox* are illustrated in Fig. 3.

Distillation

In distillation, where liquid rates are usually low, the advantage of a packing giving an excellent distribution of liquid is apparent. With *Intalox* saddles there is less tendency for liquid to migrate to the column wall than is experienced with Raschig rings and liquid redistributors will only be required in tall towers.

In vacuum distillation the advantage of low pressure drop is demonstrated once again. The temperature in the still, being governed by the pressure, will be lower when using *Intalox*, with less risk of decomposition of the residue in the still. A lower temperature in the still means a steeper temperature gradient, assuming the same source of heat, and a faster rate of distillation, which in turns means a

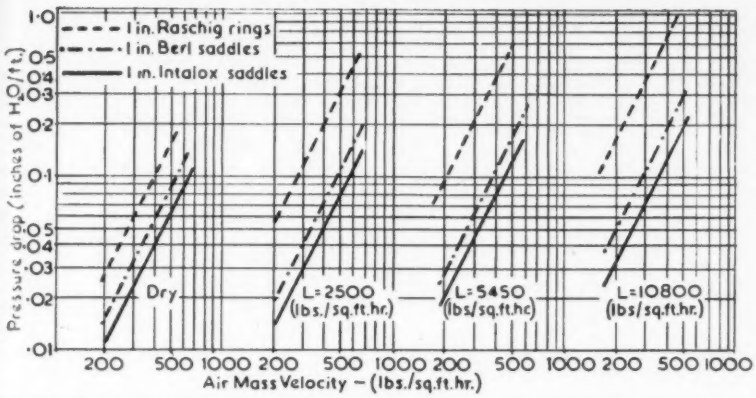


Fig. 2. Pressure drop data for 'Intalox' saddles, Berl saddles and Raschig rings in the 1-in. size. Note the uniformly lower pressure drop of 'Intalox' saddles at varying air mass velocities and at varying liquid rates.

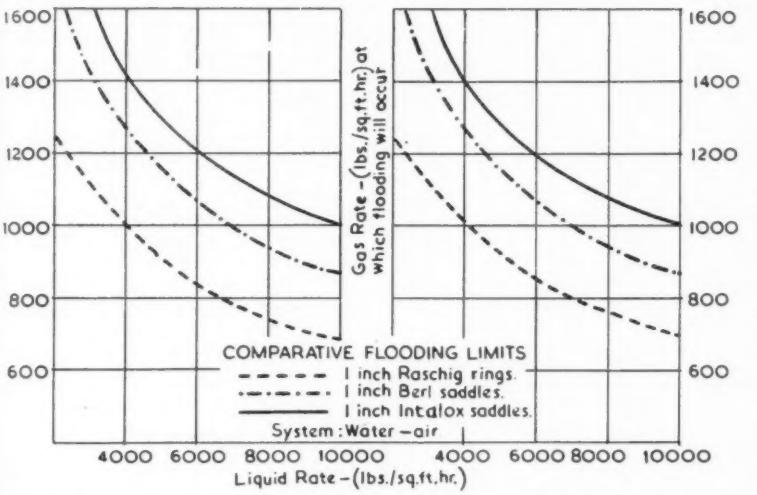

Gas Rate – (lbs./sq.ft.hr.) at which flooding will occur
COMPARATIVE FLOODING LIMITS
1 inch Raschig rings
1 inch Berl saddles.
1 inch Intalox saddles.
System: Water – air
Liquid Rate – (lbs./sq.ft.hr.)

Fig. 3. Comparative flooding limits for 'Intalox,' Berl and Raschig packings, showing that considerably higher throughput is possible with 'Intalox.'

Table I. Particulars of 'Intalox' Saddles

(Approximate values for porcelain)

Size (in.)	*Wall thickness (in.)*	*Number (per cu.ft.)*	*Weight (lb./cu.ft.)*	*Contact surface (sq.ft./cu.ft.)*	*Free gas space (%)*
2	0.275	250	50	34	70
1½	0.20	680	47	52	73
1	0.13	2,400	42	78	73
¾	0.10	6,500	48	112	67
½	0.07	20,000	50	160	65

faster production rate or, by increasing the reflux ratio, a higher quality product. The low 'holdup' of liquid in the column, a benefit derived from the smooth shape of the saddles, permits purer fractions to be separated and reduces the volumes of intermediate cuts.

The ultimate problem in the design of packed towers has for many years been the determination of the height of packing required to obtain a desired purity of product both in gas absorption and in distillation. The large number of variable factors involved make this calculation, for any specified operation, very tedious. Unless all the basic data are available and are reliable, which is very rarely the case, rule-of-thumb assumptions are made, with the result that plants are designed with an excessive safety factor.

The most satisfactory solution lies in the large-scale testing of packings under plant conditions and it is encouraging to know that an increasing number of organisations are now testing in columns of 2-ft. diam. and larger. Results of this type of work are currently appearing in the literature. A comparison of the overall capacity coefficients obtained for the absorption

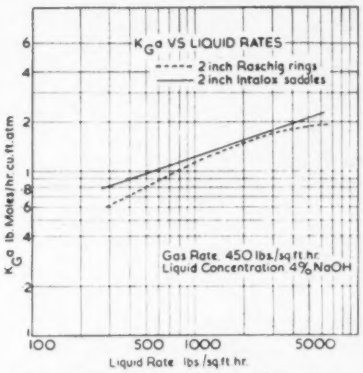


Fig. 4. Overall capacity coefficients for 'Intalox' saddles and Raschig rings in the absorption of CO_2 by caustic soda.

of CO_2 by caustic soda using *Intalox* saddles and Raschig rings is shown in Fig. 4. These results were obtained in a tower of 30-in. diam. It is instructive to note that the superiority of the saddles is most marked at low liquid rates, due to the good liquid distribution obtained, and at high liquid rates, where the greater capacity of saddles is illustrated.

It should be noted that the maximum throughput for gas is much higher in the case of *Intalox* saddles and this will still further increase the K_Ga as compared with Raschig rings.

Acknowledgment is made to the United States Stoneware Co., the patentees of *Intalox* saddles, for use of the data in Figs. 1-4.

Sulphite pulp from pine

As the second pulp mill in the world to produce sulphite pulp from pine—after Stora Kopparberg's Skutskär mill which pioneered the method—another large Swedish forest industry group, Mo och Domsjö A.B., has now started full-scale production at their Domsjö mill. Since the chemicals used for the sodium sulphite method are more expensive than in the conventional process, special apparatus has been installed in order to ensure an almost complete recovery of the chemicals. Besides broadening the raw material basis the new sulphite process is also claimed to offer pulp-makers facilities for a wider range of pulp grades.

Safe Handling of Dangerous Materials in Atomic Industry

THE unprecedented safety problems involved in the majority of operations in the atomic energy industry are such that too much cannot be said about the extreme caution needed in design, operation and maintenance. The latest annual report of the Chief Inspector of Factories, to which reference was made in* CHEMICAL & PROCESS ENGINEERING *last month, gave a useful review of the precautions necessary in certain operations. These are briefly summarised below.*

Processing special metals

Much research is being undertaken to find a suitable canning material with a low thermal neutron cross-section and a higher melting point than the magnox alloy fuel cans used at Calder Hall. Beryllium, zirconium and niobium possess these qualities, but their preparation and fabrication present special problems. Beryllium and its compounds in the form of fine dust or fume are extremely toxic. It is obtained from the fluoride by magnesium reduction and then fabricated by powder metallurgy. Purification of the vapour or flake metal from the reduction process is done by remelting, reswarfing, grinding and then pelleting and sintering, most of which processes give rise to dust or fume. Complete enclosure is essential with extremely efficient exhaust and dust-collecting systems, and it is also necessary to ensure that the dust does not escape from the factory. Frequent checking for atmospheric contamination in any workroom must be carried out.

Zirconium, so far as is known, has little or no toxic hazard, but is very difficult to extract from its ore. Here, magnesium reduction of the chloride is used and the spongy material obtained after leaching is then arc-melted *in vacuo* in a water-jacketed copper crucible. As the melting point is about 1,880°C., there is a danger of evaporation of the crucible and reaction of the molten metal with the cooling water. Another complication is that finely divided zirconium presents an extremely high fire hazard.

Fabrication of niobium is effected by preferential solution of tantalum contaminants in organic solvents from an acidified aqueous phase. These solvents are also highly inflammable. The metal is obtained by reducing the oxide with aluminium or magnesium, which must avoid the inherent fire risks in the thermit-type reduction processes which are so useful in the manufacture of these rare metals.

*H.M.S.O., 5s. 6d.

Uranium processing

In the 'enrichment' of uranium by the diffusion process precautions must be taken against inhalation and ingestion of natural uranium. The process is carried out in a completely closed plant and samples are taken periodically to check for any possible contamination due to accidental leakage. A more serious hazard arises when it is necessary, for maintenance purposes, to remove parts of the plant, and such parts must be thoroughly decontaminated before going to the workshops.

As uranium becomes increasingly enriched, a point may be reached where the mass of Uranium-235 is sufficient to sustain a chain reaction which could result in a serious fire or explosion. This must be guarded against by taking the greatest care in the design and operation of the plant, and also in any subsequent handling of the finished product or of any waste or swarf produced.

Hazards with irradiated fuel rods

To ensure protection to personnel from intense beta and gamma radiation, and from the inhalation or ingestion of radioactive material, a combination of shielding, mechanical handling and interlocking is used in removing rods from a reactor and processing them. All manipulation is carried out by remote control.

Instrumentation of reactors

In the instrumentation of nuclear reactors the first concern is to ensure safety in the operation of control-rod mechanisms. Many things can go wrong should the electricity supply fail and to meet this risk duplicate, and sometimes triplicate, safeguards must be fitted. The multiplication of services must in some cases be carried through the whole plant.

In designing the instrumentation system there are many other factors to be considered which call for new principles and practice in inherent stability, reliability and 'fail-safe' features. Human failings, such as mental aberration and inadvertent action, have to be guarded against, and sequences fully interlocked.

Effluent Piping

To the Editor.

SIR,

In an article entitled 'New Ideas in Effluent Piping' in your June issue you refer to a chemical works in South Wales where chlorinated brine had to be discharged at a temperature of 60°C. 'Formerly,' you say, 'a chlorinated rubber-lined, 6-in. metal pipe, several hundred feet in length, was used, but after barely a year it was so corroded that it had to be scrapped. Continued use of rubber-lined piping would have involved expensive replacement at least once a year.'

I feel that this passage may be misleading, since the pipeline referred to would appear not to be a rubber-lined pipe at all but a pipe painted internally with a chlorinated-rubber paint. Admittedly this might be quite unsuited to the conditions mentioned.

There is no indication in your article of the strength of the chlorinated brine solution but it is highly probable that piping lined with rubber or ebonite of normal thickness would give lengthy and satisfactory life. Linings compounded to meet such conditions could be applied by any member of this Group.

Yours faithfully,

T. H. BROOKE,

*Chairman, Plant Lining Group,**
Federation of British Rubber and Allied Manufacturers,
43 Bedford Square,
London, W.C.1.

The information quoted by Mr. Brooke was obtained from British Geon Ltd. and was published by us in good faith. The following letter has been received from British Geon Ltd.:

We would confirm that the installation to which your correspondent refers was in fact of metal pipe coated internally with chlorinated rubber. To describe it as 'chlorinated rubber-lined' might therefore introduce some ambiguity, for which we must apologise.

The purpose of the illustration was, however, not to suggest the lack of resistance to corrosion of chlorinated rubber or ebonite—which is not doubted—but rather to underline the obvious practical and economic advantages of using a rigid, unlined, corrosion-resisting pipe such as that made from *Geon* RA170 high-impact PVC.

* Members of the Plant Lining Group are: B.T.R. Industries Ltd., Dexine Rubber Co. Ltd., Dunlop Rubber Co. Ltd., Nordac Ltd., Redferns (Bredbury) Ltd., St. Helens Cable & Rubber Co. Ltd.

The Technology of

ZIRCONIUM AND ITS ALLOYS

By D. R. Harries, B.Sc., Ph.D.
(*Atomic Energy Research Establishment, Harwell*)

Part 1.—Production and cost; extraction; melting; fabrication; surface treatment; scrap recovery; joining

THERE are essentially six metals which can be used in the core of a thermal reactor fuelled with natural uranium of low enrichment: beryllium, magnesium, aluminium, zirconium, niobium and steel. The thermal neutron absorption cross-sections and melting points of these metals are listed in Table 1.

Beryllium, the most attractive from the nuclear standpoint, is relatively scarce and expensive, has limited ductility and requires special fabrication techniques because of its toxicity. Aluminium and magnesium alloys are used as canning materials in British gas-cooled reactors, but cannot be used in future reactors of this type operating at higher temperatures because of their poor creep properties and low melting points. The low neutron cross-section and high melting point of zirconium, together with its high resistance to corrosion, recommend the metal for use as a container for fissile material and for other 'in-pile' equipment in nuclear reactors. The physical properties of zirconium are summarised in Table 2. Zirconium has hitherto been used mainly in the form of alloys for fuel element cladding and as a diluent for uranium fuel in pressurised water reactors in the U.S.A. The use of zirconium as a cladding material in pressurised water reactors resulted in the development of a series of alloys known as *Zircaloys*:

Zircaloy 1: Zr + 2.5% Sn.

Zircaloy 2: Zr + 1.5% Sn + 0.12% Fe + 0.05% Ni + 0.10% Cr.

Zircaloy 3: Zr + 0.25% Sn + 0.25% Fe.

Zircaloy 2 has been used most extensively, as this alloy combines good corrosion resistance, low neutron absorption and improved mechanical strength.

Niobium and steels, with higher neutron cross-sections, may also be acceptable for use in thermal reactors, but only in thin sections.

Before the advent of nuclear power for electricity generation, zirconium was used only on a small scale, mainly as a reduction medium in electronic equipment, as photographic flashlight material and as a constituent in pyrotechnics. The realisation that it was a suitable material for nuclear reactors has led to an increase in production, with a simultaneous decrease in cost. This is shown in Table 3, which gives the estimated production figures and costs of zirconium in the U.S.A. over a period of years.

Table 1. Comparison of Main Constructional Metals

Metal	*Thermal neutron absorption cross-section (barns)*	*Melting point (°C.)*
Beryllium	0.010	~1,300
Magnesium	0.063	650
Aluminium	0.23	660
Zirconium	0.18	1,845
Niobium	1.1	~2,500
Iron	2.5	1,533

Table 2. Physical Properties of Zirconium[1]

Atomic number	40
Atomic weight	91.22 (chemical) 91.24 (physical)
Packing fraction	$-(6.5 \pm 0.9) \times 10^{-4}$
Density (20°C.)	6.49 ±0.001 g./c.c.
Boiling point	3,577°C.
Crystal structure:	
α (R.T. to 863°C.)	C.p.h.
β (863°C. to m.pt.)	B.c.c.
Thermal expan.	5.8×10^{-6}/°C.
Thermal conduct.	0.040 cal./cm./sq. cm./sec./°C. at 25°C.
Specific heat	0.0659 cal./g./°C. at 25°C.
Heat of fusion	60.3 cal./g.
Electrical resistivity	39.84 microhm/c.c. at 0°C.
Temperature co-efficient of resistivity	44.0×10^{-4}/°C. from 0 to 200°C.

Table 3. Production and Cost of Reactor-grade Zirconium Sponge in U.S.A.[2]

Year	*Production (1,000 lb.)*	*Price ($/lb.)*
1950	31	35
1951	138	
1952	211	
1953	201	22
1954	312	
1955	427	
1956	475	12
1957	1,172	
1958	2,200	4.53—7.72

Table 4. Typical Analyses of Iodide and Sponge Zirconium

Impurity	*Iodide Zirconium (p.p.m.)*	*Sponge Zirconium (p.p.m.)*
Aluminium	30	75
Boron	—	<10
Chlorine	—	600
Chromium	30	100
Hafnium	40	100
Iron	200	1,000
Lead	<10	50
Magnesium	<10	600
Manganese	<10	50
Nickel	30	70
Titanium	10	50
Vanadium	—	50
Carbon	100	200
Oxygen	200	1,500
Nitrogen	10	100
Hydrogen	20	30

Current costs

Currently, American zirconium ingot in lots of 500 lb. or more can be obtained for about $23/lb., while wrought plate sells for about $30. Prices for zirconium tubing are quoted at between $40 and $60/lb., depending on dimensions and tolerances.

The approximate costs of reactor-grade sponge in Britain are 75s. to 152s./lb.[3]

The reactor-grade metal prices quoted below are based on a sponge price of from £2 15s. to £3/lb.

Rod (0.4 to 4 in. diam.): £10 to £15/lb., depending on size and quantity required.

Squares or flats (from 4 to 12 in.): About £10/lb., plus up to £1/lb. for machining and cutting to length.

Sheet (2-ft. standard width; 0.030 to 0.10 in. thick): About £12 to

£14/lb., plus up to £2/lb. for off-standard widths in small quantities.

Wire (0.04 to 0.4 in. diam.): £15 to £27/lb.

Tube: About £15 to £35/lb., depending on diameter and wall thickness.

These prices are continually under review and are expected to fall appreciably if Britain's zirconium requirements increase in the next few years.

A recent comparison[4] of the economics of zirconium alloys and stainless steel in nuclear reactors, based on a study of five power reactors with fuel materials varying from natural to highly enriched uranium, led to the following conclusions:

(i) Zirconium alloys can be used economically for permanent parts of commercial power-producing reactors when fuelled with uranium enriched up to at least 4% U^{235}.

(ii) Zirconium alloys should be used to clad natural uranium-type fuel elements.

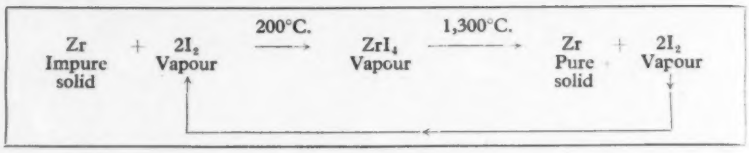
(iii) At current mill product prices, zirconium alloys are definitely competitive with stainless steel at $5/lb. for fuel cladding in slightly enriched reactors where the zirconium can be substituted on approximately a volume-for-volume basis.

The use of the superior nuclear properties of zirconium instead of stainless steel makes possible savings through the use of uranium of lower enrichment, reduction in the critical mass of uranium, or a combination of both. On the other hand, zirconium and its alloys cost more than stainless steel. The economic incentive to use zirconium is therefore dependent on the relative magnitudes of the saving in fuel costs compared with the additional material cost of zirconium.

Extraction

Although previously classified as a rare metal, zirconium is the ninth in abundance in the earth's crust, being present in greater quantities than nickel, copper, zinc and lead. The most important sources are zircon ($ZrSiO_4$) and baddeleyite (ZrO_2). These zirconium minerals always contain 2 to 3% hafnium, which is undesirable because of its high neutron absorption cross-section (105 barns). Apart from this, the hafnium appears to exert little influence on the other properties of zirconium.

Two methods are currently used to produce zirconium on a commercial scale: (i) the Van Arkel or iodide process, and (ii) the Kroll process.



Van Arkel process[1]

In its simplest form this process may be represented by the above equation.

A very pure metal is produced by the decomposition of the zirconium tetraiodide vapour by an electrically-heated filament, on to which the metal is deposited. The iodine from this reaction is allowed to react with the impure zirconium in another part of the system. Since this method requires the use of zirconium made by other processes, the end-product is prohibitively expensive for most commercial purposes and the Kroll process is generally used for large-scale production.

Kroll process[1]

This process may be conveniently divided into two stages: first, chemical processing designed to yield a suitable compound from which reduction to metal may be achieved; and, second, metallurgical processes in which a metallic sponge is produced. These stages may be further subdivided into steps of the operational sequence and these are as follows:

Chemical processing

(*a*) Purification of zircon.
(*b*) Carburisation of zircon.
(*c*) Chlorination of the carbide.
(*d*) Purification and densification of crude chloride.
(*e*) Hafnium separation.

Metallurgical processing

(*f*) Reduction of pure chloride with molten magnesium to produce sponge zirconium.
(*g*) Separation of salts from the reduced zirconium.

Methods of separating hafnium from zirconium have been reviewed by Hudswell and Hutcheon.[5] Of these, the solvent partition of thiocyanates has been developed and used in Britain. In this system the hafnium thiocyanate is extracted preferentially in a hexone-thiocyanic acid mixture from an aqueous solution containing zirconium and hafnium. The process finishes essentially with the hydrous zirconium oxide, which is not suitable for direct reduction to the metal and has to be chemically treated to produce anhydrous zirconium tetrachloride. The yield of zirconium containing 0.03 to 0.04% hafnium is about 90%.

The production of zirconium by the Kroll process may be illustrated by the simple equation:

$$\underset{\text{Vapour}}{ZrCl_4} + \underset{\text{Liquid}}{2Mg} = \underset{\text{Solid}}{Zr} + \underset{\text{Liquid}}{2MgCl_2}$$

This reduction is carried out in an evacuated and inert-gas-filled, stainless-steel vessel. The chemical treatment to remove hafnium removes, or considerably lowers, most of the other impurities present, so that the purification and densification step becomes less important and it is possible to perform the operation of purification and reduction in one step in one vessel.[6]

Although the Kroll zirconium is impure by comparison with iodide zirconium, it is possible by suitable alloying (*e.g. Zircaloy* 2) to use the sponge base zirconium in reactors without an additional refining operation.

Typical analyses of iodide and sponge zirconium are given in Table 4.

Melting

Consolidation of the zirconium sponge or iodide wire to ingot form is a necessary intermediate step before fabrication techniques can be applied. The melting of zirconium is more difficult than with other metals because of the chemical reactivity of the material at high temperatures. Zirconium can be induction melted, but since it dissolves all known crucible materials contamination results with detrimental effects on the properties. Consequently, zirconium sponge is generally consolidated by consumable electrode, arc melting in inert gas or vacuum using water-cooled copper crucibles. The metallic sponge is compacted in the form of bars which are welded together and used as the electrode. Alloys are made by incorporating the additions in the electrode and double melting to give homogeneity. This is generally carried out in production by direct remelting of the first melt ingots, but on an experimental scale by extruding the first melt ingots to the original electrode size before remelting.

Fabrication

The fabrication of zirconium and its alloys is not particularly difficult, although certain precautions not encountered with the more common

metals have to be exercised. There are two main problems in fabrication:

(i) The tendency of the metal to stick or gall in the dies.

(ii) The necessity to avoid contamination by reaction with air and furnace atmospheres during preheating and annealing operations.

Galling can be overcome by using lubricants, but with zirconium it is necessary to produce a foundation to hold the lubricant. The most satisfactory method of doing this is to form a thin oxide skin on the surface. The depth of the oxidation is controlled and limited to produce the desired effect without embrittling the metal. A chemical bath which produces durable coatings on zirconium and its alloys has the following composition:

50 g./litre $Na_3PO_4.12H_2O$
50 g./litre $KF.2H_2O$
26 ml./litre HF

The part is agitated in the bath for 2 to 3 minutes until the reaction ceases, when a grey film is formed on the surface. A mixture of molybdenum disulphide and grease is a satisfactory lubricant in combination with this coating.

Avoiding contamination of zirconium during fabrication or heating before fabrication is a different problem; oxygen, nitrogen, carbon and hydrogen are all possible contaminants under such conditions. Contamination can be avoided by the use of inert gases or operating *in vacuo*, but in large-scale operations such means of protection would be very costly. The problem of contamination has been overcome by enclosing the zirconium ingots in evacuated mild-steel or copper sheaths, which permit higher working temperatures than can be used with the unprotected metal and contribute to the ease of fabrication.

Zirconium ingots have been fabricated into most of the standard metal shapes, including plate, sheet, tube, rod, foil and wire.

The rolling of sheet and plate is carried out by the hot breaking down of ingots by forging and rolling, followed by cold reductions with intermediate heat treatments. Contamination on small-scale work is minimised by canning the ingots in copper or mild steel and it is necessary to remove the sheath, vapour blast and pickle off the oxide before the last few passes to obtain a bright finish. For strip greater than 0.15 in. thick, 10% reduction per pass is considered a maximum and the total reduction between anneals should not exceed 35%. For thinner sheet the reductions between passes and between anneals can be increased.

A greater part of the development work on zirconium fabrication has been directed to the hot extrusion of tubes and their subsequent cold reducing and drawing. Since the prevention of welding of the metal to the dies requires good lubrication, this has restricted the preparation of tube billet bores to machining rather than piercing. The billet is drilled to a diameter of 0.15 in. greater than the mandrel size to be used and canned completely in copper. After extrusion the copper is pickled off in nitric acid and the slightly ridged outside lightly ground to remove the thin alloyed film. The hollow is cold drawn to tube with area reductions of 16 to 20% per pass and at a drawing speed of 20 ft./min. Graphite is used as a lubricant on the outside of the tube. After a few passes the tube is annealed at 650 to 700°C. for a time dependent on the wall thickness. Tube reducing is practicable for heavier reductions, but finishing to size by mandrel drawing is usually employed.

Preliminary results suggest that piercing on the extrusion press is a practical proposition and would result in considerable saving in the preparation of billets for the extrusion of tube. An alternative method to copper or mild-steel canning for extrusion which warrants further study is the Ugine-Séjournet process, which employs glass as a lubricant. It is necessary to develop glasses which do not react with either zirconium, its oxide or both at the extrusion temperature.

Surface treatment

The corrosion resistance of zirconium and its alloys in high-temperature water is related to both the composition and the condition of the surface following machining, hot working and annealing. The presence of traces of chemical contaminants, such as fluorides and perspiration, also has an adverse effect on the corrosion resistance.

Difficulties arising from these sources can be eliminated and a bright finish produced by degreasing and removing about 0.002 in. of metal by shot or vapour blasting and pickling in an aqueous solution of approximately 45% concentrated nitric acid and 3 to 10% hydrofluoric acid. A large ratio of etchant volume to component surface area is required, as the zirconium-acid reaction is exothermic and the etchant temperature should be maintained below 50°C. The addition of wetting agents to HNO_3/HF etchants lowers the dissolution rate at elevated temperatures.[7] Contamination occurs when the etchant is not thoroughly water-rinsed from the surfaces or when it is allowed to dry on the specimen. If the specimens are not transferred quickly from the etchant to rinse, the etchant becomes spent and deposits the residual reaction product on the surfaces. Rinsing zirconium and its alloys in aqueous nitric acid (25 vol. %) after etching has been demonstrated to be a valuable addition to the pickling operation as the time required for the transfer from the etchant to the rinse need not be as short as when water-rinsing only is employed.[7]

Scrap recovery

A major factor in the economics of zirconium utilisation is the recovery of scrap contaminated by pick-up of carbon, oxygen, nitrogen and several metallic elements and which is produced in fabricating operations.

Heavy scrap can be cleaned and remelted, but fine scrap, such as turnings, exhibiting a large surface area per unit volume of metal, is excessively contaminated. Such scrap must be completely recycled by burning to the oxide, converting to the tetrachloride and then reducing to sponge. However, this is expensive and, further, machine turnings must be handled carefully to allow a minimum exposure to air and moisture. Several serious fires and occasional explosions with fatal results have occurred due to improper scrap handling.[8]

In the manufacture of zirconium-clad fuel elements for the experimental boiling water reactor (E.B.W.R.) 46% of the zirconium received in the form of 1,000-lb. ingots was accounted for in the finished product and only half of the scrap was of a type suitable for direct recovery.[2] Poor as this seems, it is probably a great improvement over other fabrication records and indicates that steps can be taken to reduce scrap losses. It is felt that additional improvement in the reduction of scrap and direct recycling of such material is possible and must be accomplished if zirconium costs are to decrease greatly. Methods of reclaiming fine scrap would also aid in reducing costs.

Joining

(a) **Welding.** The argon-arc welding process is an obvious choice for fusion welding such a reactive metal as zirconium, which possesses a combination of properties making it amenable

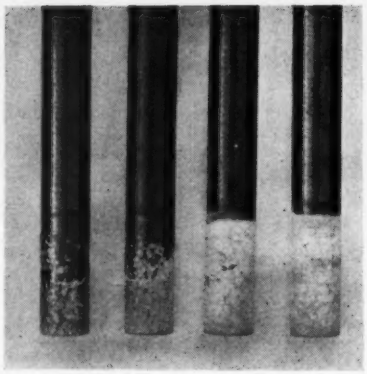
to joining by this technique. The liquid metal flows quite readily and it has a high solubility for its own oxide. The metal has a low coefficient of expansion and this contributes to low distortion during welding. Both alternating and direct currents have been used, but straight polarity d.c. (electrode negative) is now preferred.

The properties of zirconium and zirconium alloy welds are dependent not only on the composition of the base material, but also on the extent of the contamination introduced during welding. The argon flowing from the standard tungsten-arc welding torch does not provide sufficient shielding of the weld areas and modifications of this process involving an inert-gas backing groove and trailing shield for welding reactive metals have been described.[9, 10] Butt welds have been made by this technique in zirconium sheet (0.02 to 0.06 in. thick) with no edge preparation, except careful shearing to produce straight edges and without filler rod, such that the hardness of the welds is not greater than that of the parent sheet.[11]

Welds made using the modified tungsten-arc welding technique are satisfactory for many applications and have good corrosion resistance in high-temperature water if pickled before corrosion testing.[12]

Zircaloy 2 and *Zircaloy* 3 butt welds, which are corrosion-resistant in 325°C. water in the 'as-welded' condition, can be made if the specimens are first pickled and the welding is done in a chamber that has been evacuated to less than 3×10^{-4} mm. Hg. and back-filled with high-purity argon to 160 mm. welding pressure or helium to atmospheric pressure.[10, 13] The corrosion resistance of the welds is related to the nitrogen content of the welding chamber atmosphere, 100 p.p.m. nitrogen being sufficient to cause enhanced corrosion of the specimens tested in the 'as-welded' condition.[14] The effect of nitrogen content of the welding chamber atmosphere on the corrosion resistance of *Zircaloy* 2 welds in 325°C. water is shown in Fig. 1. Welds made in the best atmospheres are corrosion resistant in the 'as-welded' condition, but welds made in poor atmospheres or in atmospheres contaminated with up to 800 p.p.m. nitrogen can be restored by post-welding surface treatment.[14]

The work done so far has not been extensive enough to establish conclusively the extent to which the above rigid specifications can be relaxed whilst still maintaining a high resistance to corrosion in 325°C. water.



Effect of nitrogen content of the welding atmosphere on the corrosion resistance of 'Zircaloy 2' butt welds in 325°C. water. Nitrogen contents are, left to right: 100, 200, 400 and 1,000 p.p.m. (*After Purchas* et al.[14])

Resistance welding is an attractive process for welding zirconium and its alloys, as the problem of atmospheric contamination may not be as serious because the weld is localised and of short duration. Sound joints have been made in zirconium[15] and *Zircaloy* 2[14] using projection welding techniques without inert-gas shielding. If the superficial contamination formed during welding is removed by pickling, *Zircaloy* 2 welds have good corrosion resistance in 325°C. water.[14]

The joining of zirconium and its alloys to other metals, such as stainless steel, is difficult because of the tendency to form brittle intermetallic compounds. Since iron, chromium and nickel all form brittle intermetallic compounds with zirconium, any welding process which produces a relatively large fusion zone will produce a brittle bond. Consequently, ordinary welding techniques do not consistently produce crack-free joints or joints that have reliable impact resistance and ductility. Preliminary evidence suggests that, by making use of the differential thermal expansions, diffusion bonds of good quality can be obtained between austenitic stainless steel and *Zircaloy* 2 tubes by heating the joint at 1,010 to 1,020°C. for 30 to 80 min. in a chamber evacuated to 0.05 microns.[16, 17] These joints have not failed after thermal cycling 200 times between 38 and 315°C. or after pressure cycling 100 times between 100 and 3,500 p.s.i.

(**b**) **Brazing.** Zirconium is difficult to braze because of the refractory nature of the oxide film and it forms brittle intermetallic compounds with most of the common brazing metals. None of the commercial fluxes remove zirconium oxide and promote wetting by the brazing alloys. However, zirconium is self-fluxing in that it rapidly dissolves its room-temperature surface oxide at brazing temperatures.

The Armour Research Foundation in America have investigated a large number of metals and alloys as potential brazing materials for *Zircaloy* 2 and 3.[18] The brazing was carried out without the use of a flux by induction-heating the parts in an evacuated (<1 micron) and helium-filled bell jar and allowing the brazing alloy to flow into a lap joint. Four alloys produced joints resistant to attack by 360°C. water for 1,200 hr.:

(i) *Zircaloy* 2 + 4% Be.
(ii) Ni + 7% P (*Kanigen*).
(iii) Ni + 20% Pd + 10% Si.
(iv) Cu + 20% Pd + 3% In.

All these alloys melt above the α/β transformation temperature of zirconium. The *Zircaloy* 2 + Be alloy had the best flow properties, shear strength and corrosion resistance. *Kanigen* has the advantage that it can be plated. The only alloy that can be fabricated by forging and rolling is the Cu-Pd-In alloy.

(**c**) **Zirconium canning of fuel elements.** Zirconium owes part of its popularity in reactors to the fact that it is compatible with uranium and UO_2, the rates of reaction below 600°C. being insignificant,[19] and can therefore be used as a fuel-element cladding material. Strong and ductile metallurgical bonds can be formed between uranium and uranium alloys and *Zircaloy* 2 by co-extrusion.[20] The attainment of such a bond enables high heat ratings to be achieved and the diffusion rate of uranium into zirconium at the temperatures normally encountered in a pressure water reactor is so slow that thin claddings can be used. Further, recent studies have indicated that ammonium fluoride (NH_4F) solutions readily dissolve zirconium and its alloys.[21] Thus the problem of removing zirconium cladding from irradiated fuel elements may become simpler and permit more economic recovery of unused fuel.

The second and concluding part of this article will deal with the corrosion resistance and mechanical properties of zirconium and its alloys.

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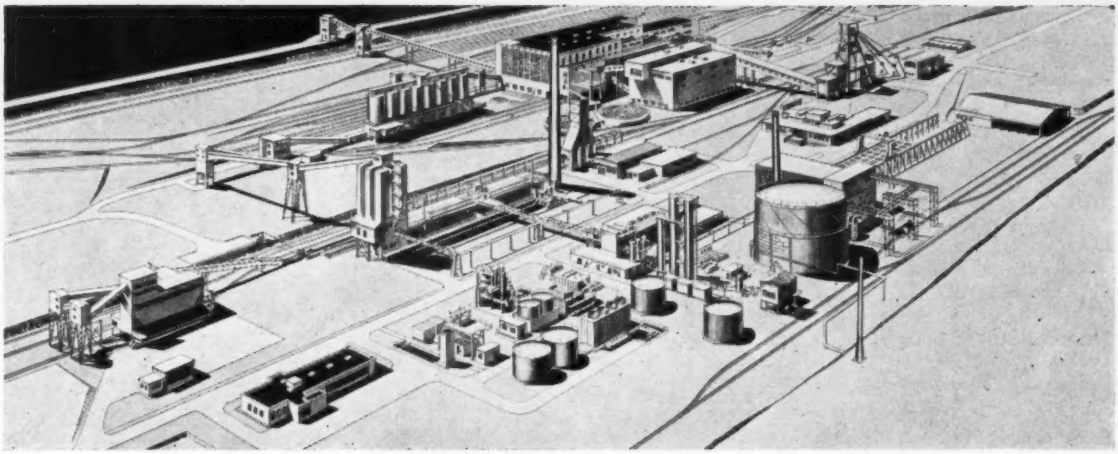


Artist's impression of the Murton coking and by-products plant.

Central Control in a Coke and Chemicals Plant

★ At Murton, centralised instrumentation and control systems provide a degree of automatic control never before attained in a coking plant.

★ Marking the new trend in economical coal mining and coal treatment, the plant is part of a scheme for a combined mine, washery and coke-producing unit.

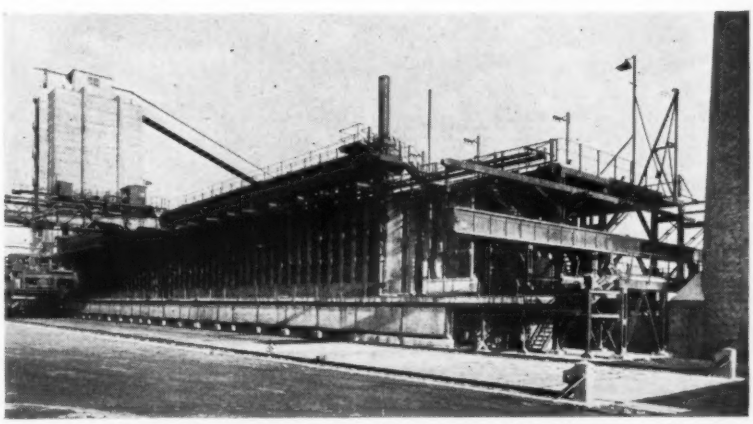
★ As well as 7½ million cu.ft./day of purified gas, chemical by-products such as concentrated ammoniacal liquor, tar and about 1 million gal. p.a. of crude benzole will be produced.

THE big new coke-oven and by-products plant of the Durham Divisional Coal Board, recently started up at Murton, Co. Durham, is provided with an advanced system of centralised instrumentation and control. There are three systems covering the whole of the coal- and coke-handling plants: the water and steam services; the tar, concentrated ammoniacal liquor and benzole recovery plants; the gas producer plant, gas purification and compression.

The coking plant has a carbonising capacity of 1,000 tons/day of coal from which some 250,000 tons p.a. of high-grade metallurgical coke will be produced. Designed and constructed by the main contractors for the project, Woodall-Duckham Construction Co. Ltd., the coke-oven installation comprises two batteries of 25 ovens, with provision for the addition of a third battery in the future. The ovens are designed for heating either by coke-oven gas, using the 'underjet' system, or by producer gas if producer-gas mains are added.

Included in the installation is a comprehensive coal-crushing and blending plant with storage capacity for 3,200 tons. Surface equipment at the nearby collieries has been modernised and there is a new washery with a capacity of 750 tons/hr. of run-of-mine coal. Coal over $\frac{1}{16}$ in. in size is cleaned by dense medium separation in a Chance sand flotation washery; the $-\frac{1}{16}$ in. material is cleaned in a *Unifloc* froth flotation plant.

The by-product recovery plant at Murton is of the indirect type, in which the gas is cooled and washed for the recovery of tar and ammoniacal liquor.



The pusher side of the oven batteries with the pusher machine and ovens coal bunker.

Instrumentation and control

The principal control system is that associated with the by-product and benzole plants. A graphic panel some 40 ft. long provides minute-by-minute information of the flow of coke-oven gas, producer gas, ammoniacal liquor, tar, benzole, wash oil, water, steam and air. Designed by Woodall-

Duckham and manufactured by Foxboro-Yoxall, the panel consists of a central graphic section with wing panels at each end and employs about 80 controllers and recorders together with pilot indicator lights, alarm signals and other devices.

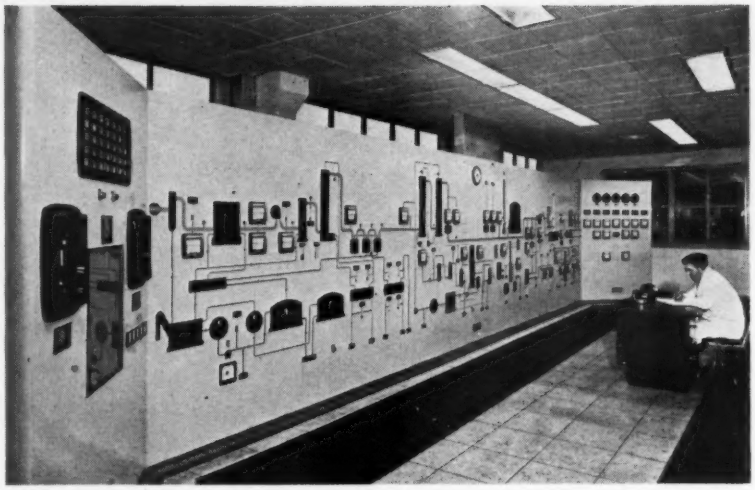
The indicating and recording instruments, of the *Consotrol* type, are actuated pneumatically; the panel-mounted controllers transmit set point signals to the actual control units located close to their associated control valves. Where a recorder is linked with a controller and functions as a control station, the set point adjustment can be made from the front of the panel.

The function of the right-hand panel is, primarily, to present essential information required for budgetary control which falls outside the scope of the graphic presentation. In particular, instruments on this wing record steam pressures, and record and integrate steam flows to the individual plants.

The left-hand wing contains two key switch potentiometers, a multiple-column mercury manometer and an annunciator board which forms part of the comprehensive alarm system. The potentiometers enable the operator to take additional temperature readings from points where continuous readings are not required, whilst the multiple columns of the manometer are arranged to demonstrate, in a clear and compact manner, the progressive changes of gas pressure in the gas purification system. These changes are recorded by pressure transmitters installed throughout the system.

A separate control desk, located in a dust-free, air-conditioned room beneath the coal-blending bunkers, provides control over coal-handling operations. The desk incorporates an illuminated mimic diagram panel which records all the information necessary for the correct operation of all machines and conveyors, from the delivery of washed coal at the blending bunkers until it is discharged into the ovens bunker. Switches incorporated in the desk are used to stop and start the coal stream, warning bells being sounded in the plant near the section to be started.

A further control desk is located at the coke screening station; it is provided with a diagram panel and various indicator lamps to show which sections of the plant are in operation and whether the coke hoppers are full or empty. High- and low-level indication for the hoppers depends on gamma rays obtained by using suitably positioned and shielded Cobalt 60 radioactive isotopes accommodated between the sides of the coke bunkers and the adjacent walls.



By-product and benzole plants control panel in the central by-product plant building.

The operation of 'pushing' the coke ovens after completion of carbonisation is controlled by the W-D *Gamma Interlock* system, which depends upon a gamma beam passing from the coke guide to the pusher machine through the oven space above the charge. The system automatically ensures that the charge cannot be pushed until both doors have been removed and the coke guide correctly aligned with the oven.

Gas production and treatment

Producer gas, for diluting the surplus coke-oven gas to a suitable calorific value for town use is manufactured in two Gibbons Heurtey H.W.J. 18 gas producers. Equipment for cooling and washing the producer gas includes two fabricated steel precoolers each superimposed above a wash box, two motor-driven gas-washing fans with provision for a third, two spray separators and a 7-ft. diam., mild-steel gas scrubber.

Crude coke-oven gas from the ovens, which is sprayed with ammoniacal liquor in the gas-collection system to remove tar, passes to the primary coolers for cooling by indirect contact with water. There are at present three tubular coolers, one being a stand-by, and each is provided with seal pots for the collection of condensate into high- and low-temperature fractions.

The coke-oven gas is delivered under pressure to the Whessoe W-D electro-detarrers, of which there are three. They are of the vertical-tube, suspended-wire-electrode type, each 6 ft. 6 in. in diameter. To cool the gas before it enters the ammonia washers and for naphthalene removal, there is a secondary cooler using petroleum oil as the cooling medium.

Below this there is a 6,000-gal. oil decanting tank which receives the drain from the cooler and separates the condensed water from the oil. Any benzole in the vapours vented from the tank is recovered by a vent scrubber fitted with ceramic rings and irrigated by an oil bleed from the pressure line serving the secondary cooler. The circulating oil is cooled by indirect contact with water in a range of six floating-head tubular heat exchangers, operating in series.

The cooled gas passes to three Whessoe ammonia washers, operating in series—any one of these, if necessary, can be by-passed. Each washer comprises four washing chambers with four centrifugal pumps to circulate the washing medium.

Benzole recovery

There are two benzole scrubbers, 11 ft. 6 in. in diam. and 106 ft. high, which normally operate in series although either can be by-passed if necessary. The wash oil from the scrubbers, enriched with benzole, is passed through two vapour-to-oil heat exchangers in which heat is transferred from the crude benzole vapour leaving the wash oil still to the cold benzolised wash oil. The condensate is returned to the benzole scrubbers. The enriched wash oil is then steam-heated in either of two final heaters before it enters the cast-iron wash oil still. The still,

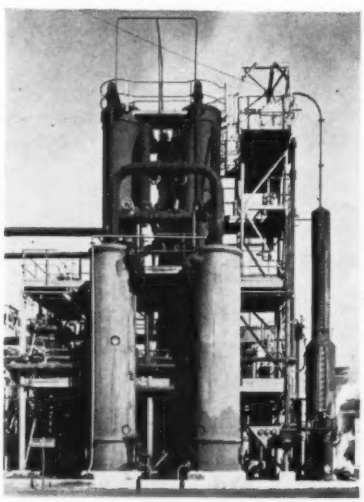
6 ft. in diam., has a series of 14 trays where the crude benzole is removed by intimate contact with steam.

The crude benzole vapour passes from the still through the vapour-to-oil exchangers to the crude benzole cooler. This consists of eight banks of galvanised piping in which the benzole vapour is water-cooled and condensed. From the cooler the crude benzole goes, *via* a water-separator and a 300-gal. running tank, to the CS_2 still, which is of cast iron with 13 stripping sections in the lower portion and 27 rectifying sections above, the whole surmounted by a reflux chamber. The crude, CS_2-free benzole is stored in two 50,000-gal. storage tanks. CS_2 recovered in the still passes through a floating-head-type condenser to a decanter from which it flows to a drumming tank equipped with a steam coil.

Concentrated ammoniacal liquor

The automatically controlled ammonia liquor plant, by R. & J. Dempster Ltd., is designed to produce liquor of 25% strength from crude coke-oven ammonia liquor which can be dealt with at the rate of 2,500 gal./hr. After preheating, the crude liquor is passed through a liquor dissociator where the specific gravity of the concentrated liquor can be controlled at a predetermined value to avoid crystallisation. The dissociator, 6 ft. in diam. and of cast-iron construction, has five bubbling trays and a bottom section into which controlled supply of open steam is introduced in order to remove the CO_2. Beneath the dissociator is the still proper also of cast-iron construction but 8 ft. in diam. It is of the loose-tray type with 16 bubbling trays and a bottom section. The free ammonia is stripped from the crude liquor and passes as vapour from the still head to the pre-heater. The hot effluent liquor from the base of the still gravitates to a 5,000-gal. sump, from which a proportion is pumped to the ammonia washers, the remainder passing through a natural-draught cooling tower to the surplus effluent sump.

From the preheater the partially condensed ammonia vapours, and a proportion of the condensate, pass through the inner tubes of a vapour condenser, in countercurrent to a flow of crude liquor. To cool the product of the condenser before feeding to the daily make tanks there is a rack-type cooler consisting of two parallel banks of eight cast-iron pipes 6 ft. long. The cooling medium is water.



The vapour/oil heat exchangers, final heaters and CS_2 column.

Technology of Zirconium and its Alloys

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Plastic Fans

Hollow plastic industrial fans are to be manufactured in the United Kingdom by Marston Excelsior Ltd., a subsidiary of I.C.I. Initially, the standard range will consist of four-bladed fans ranging from 6 to 14 ft. in diameter.

A set of hollow plastic blades may be fitted to two types of hub: the auto-variable hub, which by means of a pneumatically activated diaphragm alters the angle of pitch while the fan is in motion; and the adjustable pitch hub, which requires that the fan be stopped while a simple manual alteration of pitch is carried out. On both hubs the angle of pitch may be varied between $-15°$ and $+30°$.

Blades are made of woven glass cloth and pigmented epoxy resin, laminated as a one-piece moulding. These materials make a self-coloured blade, which is corrosion- and heat-resistant, while the method of construction gives smooth surface, high strength and low weight. The blades will not shatter or fragment and, being hollow, are extremely light; a set of blades for a 10-ft.-diam. fan weighs 58 lb. Following extensive wind-tunnel tests, the blade contour, a true aerofoil section, has been determined to give optimum performance characteristics. Fan blades of the same size are readily interchangeable.

Installations in America and in Britain are reported to be giving entirely satisfactory service moving hot dry air through heat exchangers in desert areas, moving hot moist air from water-cooling towers, moving corrosive-laden air from chemical process vats, and in large-volume ventilation systems.

To Authors of Technical Articles and Books

The Editor welcomes practical articles and notes on chemical engineering and related subjects with a view to publication. A preliminary synopsis outlining the subject should be sent to The Editor, CHEMICAL & PROCESS ENGINEERING, Leonard Hill House, Eden Street, London, N.W.1.

In addition, the Publishers and Editors of the Leonard Hill Technical Group are always ready to consider technical and scientific manuscripts with a view to publication. Correspondence should be addressed in the first instance to the Book Production Manager, at the above address.

Theory and Design of Pneumatic Transport Systems—2

By H. Bannister, Ph.D., M.Sc., D.I.C., A.M.I.Chem.E.

Part 1 of this article (July issue) reviewed the technical literature of pneumatic transport systems and it was shown that an empirical approach to design problems is still needed in spite of considerable scientific effort to correlate measured parameters. The author now concludes by describing the measurements and plant equipment needed for work in this field and giving some guidance on the results obtained and the method of using results for design purposes.

BEFORE attempting to convey a material by pneumatic transport it is sound practice to determine certain physical characteristics by normal laboratory processes. Specific gravity of particles, bulk density, screen analysis, etc., are all indispensable parameters.

Another essential measurement is that of angle of repose, the apparatus needed being shown in Fig. 1. When the cone, containing a convenient quantity of the solid, is emptied by raising the stopper a heap of material is formed on a glass or polished steel plate below. The height and circumference of this heap are measured by spirit level and string as shown and the tangent of the angle of repose calculated by the simple formula given. The angle is not a scientific entity in any sense, since many materials form heaps with sides approximating to the dotted lines, but this does not invalidate the determination. The moisture content of the material must be determined after each test.

Fig. 2 shows three typical plots of moisture content against angle of repose. Graphs 1, 2 and 3 represent materials of increasing fineness and points *A*, *B* and *C* on the graphs would give the angles of repose of the material of highest moisture content

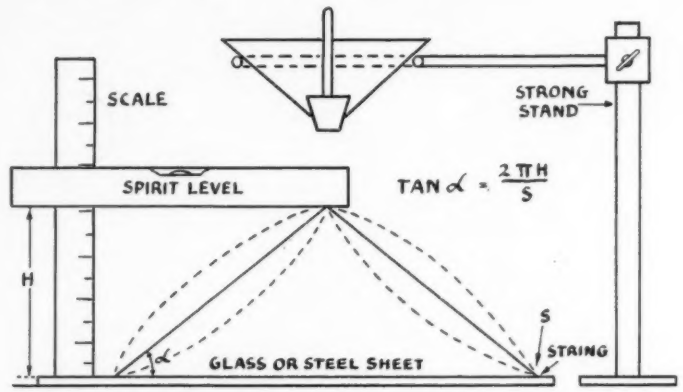


Fig. 1. Diagram of apparatus for measuring angle of repose.

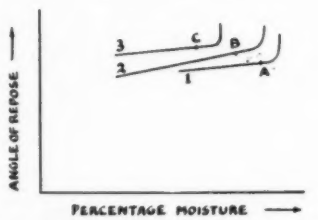


Fig. 2. Relationship between moisture content and angle of repose for three different materials of increasing fineness. Such a comparison is useful in deciding whether a material is suited to pneumatic transport.

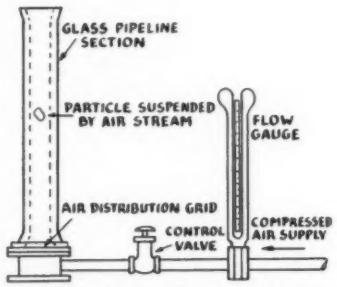


Fig. 3. Apparatus for measuring terminal velocity, another useful means of testing materials.

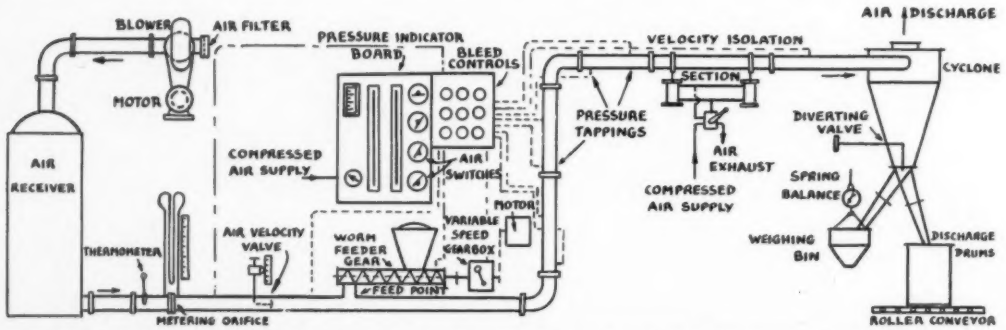


Fig. 4. Scheme of a complete plant for testing suitability of materials for pneumatic transport.

which could be conveyed by pneumatic means. If there was any danger that the moisture content could increase to the steep part of the curve, such a material would cause a pneumatic system to choke.

A further important measurement is that of terminal velocity, and for this the apparatus shown in Fig. 3 is useful. The aim is to determine the linear velocity needed in the glass pipe to keep a single particle suspended halfway up. If a material with a wide size range is on trial the largest screen fraction should be so tested. It is essential to determine 100 or so values and calculate the mean and standard deviation. A material which, because of its shape, specific gravity or other property has a high terminal velocity would be an expensive product to convey by pneumatic means and it might be as well to consider alternatives.

Plant trials

If the material passes the above tests a plant trial is worth while. Fig. 4 is a diagram of the plant required to test a material for suitability. Only the essentials are indicated, all necessary supporting structures having been omitted. Many suppliers of pneumatic transport equipment maintain systems of this kind (some very elaborate) at their premises so that clients' materials can be tested under working conditions.

As a guide to power requirements, a 10-h.p. motor driving a blower capable of 250 cu.ft/min. of free air compressed to 3 p.s.i.g. will handle a 3-in. pipeline 100 ft. vertically, with bends, or 300 ft. horizontally. Provided the radius of the bends exceeds $2\frac{1}{2}$ pipe diameters, excessive pressure loss will, in the author's experience, be avoided. The feeding gear shown is not mandatory, but is the type of which the author has had greatest experience.

The pressure tappings, which should be very numerous and equally spaced along the pipeline, are purged with air bleeds at about 3 cu.ft/hr. and a group of air switches enables a large number of such points to be connected to a small number of water manometers or pressure indicators. Pressures normally range from 0 to 50 in. w.g. in such systems. The velocity isolation section described in Part 1 should be noted and outputs essential to these determinations are measured by diverting the flow from the cyclone into the weighing bin for a fixed period of time. When determining very small pressures, such as those measured initially, when air alone is blown through the

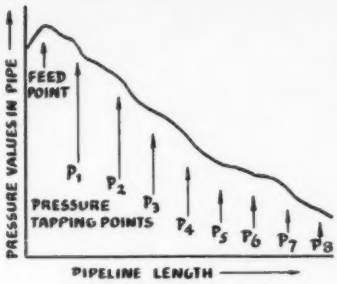


Fig. 5. Pressure graph.

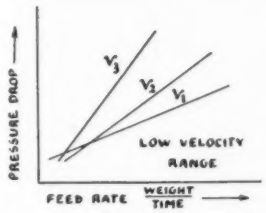


Fig. 6. Pressure drop v. feed rate.

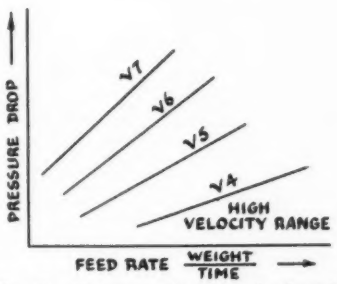


Fig. 7. Pressure drop v. feed rate.

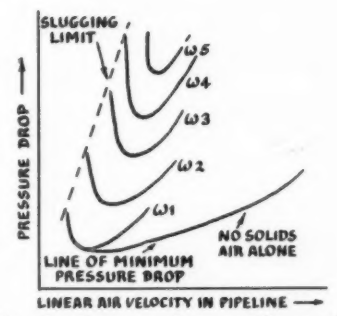


Fig. 8. Pressure drop v. linear air velocity.

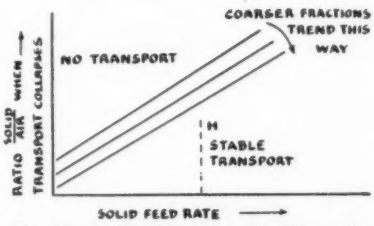


Fig. 9. Solids feed v. solid/air ratio when transport collapses.

plant, the tapping bleeds should be shut off to avoid errors. The air receiver performs the useful functions of cooling and steadying the air stream and eliminating oil mist which many blowers emit. It can be cooled by a water stream if necessary, thereby avoiding the expense of an aftercooler. The air temperature should be determined just before the metering and control section.

The technique of plant operation deserves some mention. A sort of pneumatic 'base line' should first be established by taking full sets of pressure readings for a whole range of linear air velocities with no solids in the system. This should provide a series of readings which can be reproduced at any time by clearing the plant. Then, starting with a low solids feed rate and a high air rate, throughput, full pressure readings and velocity isolation tests are carried out. The air rate is then reduced, keeping the solids rate constant, and a further set of readings taken. The air rate is again reduced and the cycle repeated until at a low air rate setting serious surging of the gauges and unstable solid flow indicates the imminence of transport collapse. Every effort should be made to define this important point as accurately as possible.

Representation of results

This procedure, repeated for a whole series of solids flow rates, gives curves similar to those in Figs. 5, 6, 7 and 8. In Fig. 5 it is seen that the pressure rises to a sharp peak just after the feed point* and afterwards falls off more or less irregularly. Fine materials show a very sharp fall in pressure in the first 10 or 15 ft of piping after the feed point and a more gradual decline afterwards. Coarser feeds show a longer energy take-up length, probably related to their lower specific surface.

Several useful graphs can be obtained by using total pressure drop across the whole system as ordinate and feed rate or linear air velocity as abscissa. Figs. 6, 7 and 8 illustrate this. In Figs. 6 and 7, V_1 to V_7 are fixed linear velocities, while in Fig. 8, W_1 to W_5 are fixed solids feed rates. It will be noted from Fig. 8 that for each feed rate there is a minimum total pressure drop at which transport is possible. To the right of the broken

*This is caused by the obstructing effect of the particles at the point of in ection, followed by a conversion from pressure to kinetic energy as the material is accelerated in the pipeline. In the author's experience no special venturis or feeder connections more complicated than a pipe tee are needed at this point in pneumatic systems.

line through these minima transport is always stable, but to the left we rapidly reach the 'slugging limit' at which transport collapses. If, for each run, the ratio of solid/air is calculated it will be found, as shown in Fig. 9, that straight lines can be drawn through points obtained by plotting solids feed against the solid/air ratio when transport collapses. This provides a diagram very useful in design work, since the graphs divide the area into two regions respectively of stable transport and no transport. The lower graphs correspond to materials of coarser grist.

Another useful curve, Fig. 10, is that which shows the relationship between the ratio air velocity/terminal velocity and the solids feed rate when transport is about to collapse. This curve tends to become asymptotic at high feed rates.

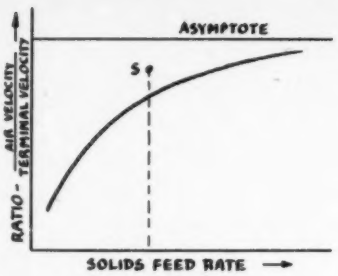


Fig. 10. Air velocity/terminal velocity *v.* solids feed rate when transport about to collapse.

Design of transport system

We now have sufficient information to enable us to outline a procedure for the design of a transport system for the material under examination. As a rule the user can fix the output required by the conveyor and the configuration of the pipework will have to conform to the geometrical layout of the premises. This fixes the route to be followed.

From Fig. 10, knowing the terminal velocity, we select at a 'safe' point above the curve the abscissa corresponding to output requirements. Such a point is shown at *S* in Fig. 10; a similar point is chosen in Fig. 9 at *H*, well inside the stable transport zone, but close enough to the lines to give maximum economy. We can now calculate the linear air velocity and from the test work we can also assess the ratio of pressure drop in the empty pipe to that when conveying at the given output with the air velocity calculated. Several practical pipe diameters should now be assumed and the ordinary Fanning equations used to calculate the pressure drop, including resistance of bends which will be needed to drive air through the empty pipe at the proposed velocity. This value should now be multiplied by the pressure ratio mentioned above. The power demands for each case can be determined from the formula:[1]

$$\text{H.P.} = \frac{Q \times P}{175} \times \frac{14.7 + P}{14.7}$$

Where H.P. = motor horse-power.
Q = volume of free air required (cu.ft./min.).
P = total pressure to which it must be compressed (p.s.i.g.).

The formula assumes a motor efficiency of 87%. The compromise between size of pipe and power demands can then be evaluated, so fixing most of the essential design details.

Recovery of solids

Nothing has so far been said about the recovery of the material from the air stream. Generally speaking, if two cyclones in series, the second of which is a special high-efficiency type, are insufficient to recover the solids from the air stream, some alternative means of conveying should be considered on purely economic grounds. The use of dust bags, special filters, electrostatic precipitators, etc., is unlikely to lead to an economic plant for pneumatic conveying applications.

REFERENCE

[1]W. G. Hudson, 'Conveyors and Related Equipment,' 3rd Ed., p. 179, etc. Wiley, New York, 1954.

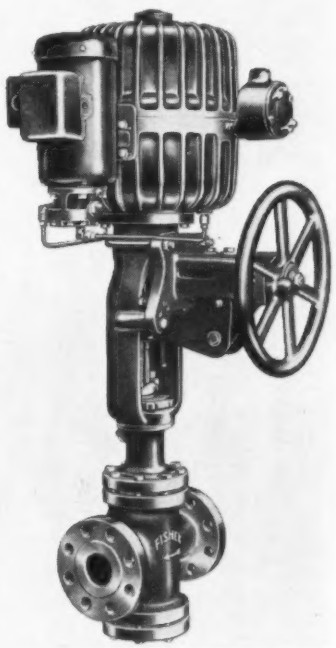
Electronic control of valves

Fisher Governor Co. Ltd. have felt the need to extend their range of control valve actuators to include those that can utilise the output signal from the latest type of electronic controllers. Two methods of positioning the valve in accordance with the requirements of the controller are now available and continuous research is going on in this field to further extend the range.

For electrically operated valves, two sizes of electro-hydraulic actuators are manufactured, giving stem thrusts of 600 or 2,000 lb.; these consist of a force motor which moves in response to the change in current imparted to it by the controller. This movement positions a flapper against two nozzles fed with hydraulic oil from a continuously running pump. The back pressure from one or other of the nozzles is led to either side of a double-acting piston which is directly connected to the valve stem. Stem movement continues until a feedback spring tension balances force created by the current in the force motor, thus returning the flapper to a balanced position.

Where the control valve is required to be of conventional design, two types of electro-pneumatic converter are available, enabling the control signal to be converted to an air signal of 3 to 15 p.s.i.g. In each type a force motor changes the electrical signal into a flapper movement which opens or obstructs an orifice fed with air at 20 p.s.i.g.; again the back pressure from this orifice is used, this time *via* a pneumatic relay, to position the final control element.

The relay in the first design is the one used in the conventional Fisher *Positrol* to which the transducer portion is connected. The unit will therefore act as a feedback device correcting the air signal to the valve topwork if the inner valve does not attain the correct position required by the electrical signal. In the second design a volume relay replaces the *Positrol* and it is used where a valve positioner would not normally be required.



Electro-hydraulic actuator type 340-A.

WHAT'S NEW

Plant • Equipment • Materials • Processes

CPE reference numbers are appended to all items appearing in these pages to make it easy for readers to obtain quickly, and free of charge, full details of any equipment, machinery, materials, processes, etc., in which they are interested. Simply fill in the top postcard attached, giving the appropriate reference number(s), and post it.

Pilot-scale drier

Designed specifically to dry air and gases for transistor manufacture, atomic energy pilot plant, furnace atmosphere dewpoint control, stainless-steel brazing and general process use on a pilot scale, a new Birlec Ltd. drier weighs 75 lb. and is readily portable. It may be supplied with various desiccants, the material of widest value being activated alumina, though molecular sieve adsorbent, silica gel or aluminium silicate may be preferred.

It is complete with two valves for the main flow, and two for the reactivation flow, two thermometers, pressure gauge, heater warning light and switch. For drying purposes, the unit is connected in circuit until the desiccant becomes saturated, whereupon it is removed and reactivated by a built-in heater system.

With a desiccant capacity of 0.25 cu. ft., the pilot drier is basically a round-ended cylinder of 9 in. diam. and a height of 3 ft. 2 in. The reactivation temperature can be controlled at any desired level between 100 and 300°C. Reactivation heating takes some 2½ to 5 hr., and a cooling period of 2 to 3 hr. is necessary. **CPE 1320**

Centrifuge

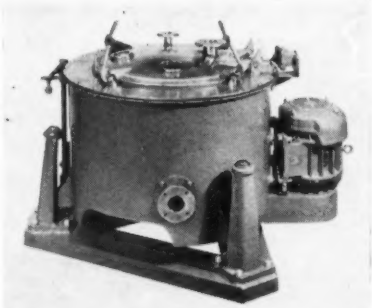
A centrifuge for use in the chemical and food industries is being offered by Power Installations Ltd. in a range of sizes from 18 in. to 60 in. in basket diameter, giving capacities from 0.75 to 14 cu. ft.

The basic machine consists of the bedplate, suspension columns, pendulum suspension and outer casing, all constructed of mild steel; the centrepiece of cast iron houses a high-tensile steel spindle set in ball bearings. The machine is underdriven, having the driving unit fixed to the outer casing, and V-belt drive through a centrifugal free-shoe automatic clutch to a V-belt brake and drive pulley situated on the centre spindle.

The brake is of the spring-compression type, with a *Ferodo*-lined brake band. Once applied, it is completely automatic and the current is cut off.

A variety of designs is available, including one in which all contact parts of the machine are of stainless steel. Filter strip retaining rings can be fitted inside the basket. The drive unit is a special high-torque electric motor, either totally enclosed and fan-cooled or flame- and explosion-proof and fan-cooled.

A less expensive version of the centrifuge can be supplied, substituting good-quality mild steel lined with ⅛-in.-thick hard vulcanite for the stainless-steel parts as described above. The lining can be specified to withstand the particular chemicals to be centrifuged. Where the fumes from the products are not injurious, a standard flat-type cover of aluminium, stainless steel or vulcanite-lined can be fitted. Sight glasses, flanged inlet and wash pipes are optional. **CPE 1321**



Centrifuge with stainless-steel contact parts.

Gives a lift to cooling-tower maintenance

To speed the removal of the induced-draught fan and fan drive gearbox for inspection and maintenance on cooling towers, a portable gantry, the *Com-Pact*, has been developed by Head Wrightson Processes Ltd.

Each main beam section is of deep, braced dual-box construction which

Portable gantry at work on cooling towers.

can be built up into a rigid beam of suitable span to clear the fan stack, with joints having a wide bearing face to eliminate any deflection under load. The tubular tripod legs are provided with a central rib-brace. The beam is coupled to the top of each leg with a wide bearing connection similar to the beam section joints.

Each leg is fitted with two swivelling self-aligning castors, and the trolley, running on the top of the beam, is fitted with four rollers and also with a hanging bar for the lifting blocks. The gantry is designed for a safe working load of 20 cwt. with a span of 24 ft. and can be used for many other lifting purposes. **CPE 1322**

Bricks for shielding

A new lead brick for use in shielding personnel against gamma, beta and

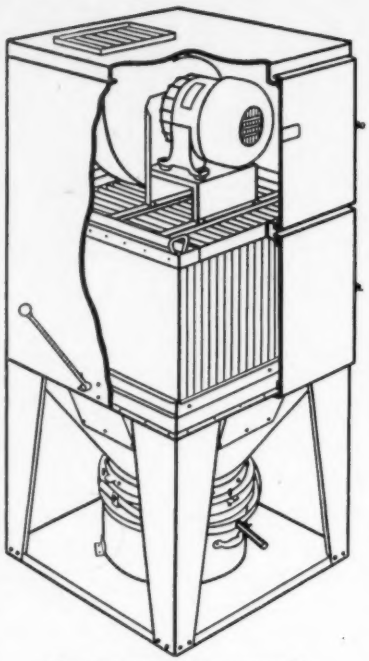
alpha rays has been produced by a special 'pressure-moulding' technique by British Lead Mills Ltd. Bricks are produced in thicknesses of 2 in. and 4 in. in the form of standard, corner, top and bottom bricks and also half or even quarter bricks which can be built up into a complete surround by virtue of their interlocking nature, to give the maximum thickness at any point of 2 in. or 4 in. or multiples thereof.

CPE 1323

Dust control at a tablet factory

In planning the *Aspro* tablet factory at Slough, Bucks., careful attention had to be given to dust control and collection, for while the powdered material is transferred from the storage bins to the hoppers and to the processing section by enclosed conveyors, the operation of the individual slugging, tableting and packing machines could cause a significant degree of dust dispersion and contamination. A system of dust control giving virtually 100% efficiency was called for. The number of machines for which dust control had to be provided was 56 and a total of 21,750 cu.ft./min. had to be handled.

The problem was handed to Dallow Lambert & Co. Ltd. and a solution eventually found in an installation based on *Dustmaster* unit filters, these being versatile units consisting of a pad-type filter element assembly, fan, motor, dust container, quick-release gear and automatic shaking mechanism all within one unit chassis.



'Dustmaster' filter assembly.

The system has now been in operation since the spring of 1958 and the degree of dust control achieved with full production is claimed to be exceptionally high. **CPE 1324**

Resin for bonding

Fully formulated polyester resin for bonding glass-fibre reinforcement to a suitably prepared vinyl sheet has been developed by Artrite Resins Ltd. Tanks and containers, ducting, pipes and various components in the chemical, food and other processing industries are examples of its application.

Resin F. 655 is formulated for the wet lay-up moulding technique and supplied ready for use requiring only the addition of a hardener just prior to moulding. The natural colour is light-buff and translucent, but it can also be supplied in shades to match the colour of the vinyl sheet. **CPE 1325**

Filter presses

Filter presses of German manufacture are being marketed in the U.K. by Durham Raw Materials Ltd., the two basic types being flush plate and frame presses, for use where the filter cake is of uniform thickness and porosity, and facilitates an effective flushing of the solids; and recessed plate presses, for use where solids are subject to blockage. Both types are available with plate sizes from $9\frac{3}{4}$ to 57 in. and mechanical or hydraulic closing devices may be used.

CPE 1326

PTFE hose

Flexible hose of PTFE and re-usable end fittings in a variety of metals are being manufactured by William Rose Ltd. Hose ranges from $\frac{1}{8}$ to 1 in. bore and the bending radius is 1 in. for a $\frac{1}{4}$-in. tube. The hose has a working temperature of –80 to 250°C. and under certain circumstances as high as 300°C. and throughout this range maintains its inherent toughness.

Re-tubing of the fittings can be carried out by the user in an emergency or returned to the manufacturer.

CPE 1327

Mills and mixes

For extremely rapid disintegration and mixing of minute quantities of substances to ultra-fine particle size a machine is available in which the grinding and mixing is carried out in stoppered vials of 2 or 5-c.c. capacity, made of plastic, stainless steel, hardened tool steel or agate. Materials can be pulverised to less than 200 mesh in 2 to 3 min. The simplest outfit of this type, offered by Glen Creston Ltd., costs £37.

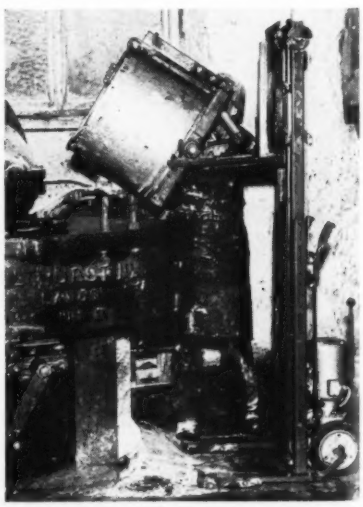
Another mill, which has been introduced at the same time, basically serves the same purpose but can cope with very much larger quantities.

CPE 1328

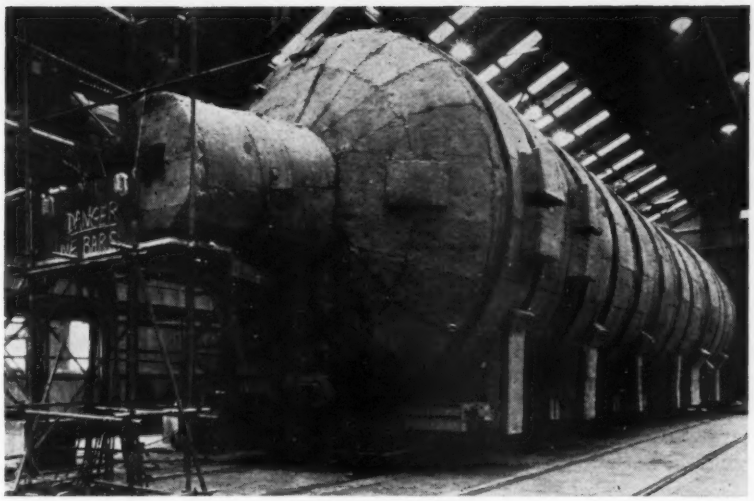
Cupola collector

The principle of operation of the Holmes-Schneible 'SW' cupola collector is that hot gases containing entrained solids mix with the air drawn in through the charging door and burn in the upper section of the cupola stack. The gases and unburnt solids then pass to the collector where expansion, washing and cooling take place before being exhausted to atmosphere.

The collector consists of an outer shell and collection trough supported on an angle ring welded to the cupola stack. The distribution head will pass any solids pumped to it, is adjustable and can be readily opened. The water leaves the cone and forms a heavy water curtain through which the gases pass. The water and collected solids impinge upon and run down the inside of the collector casing into a trough. This trough is self-draining and the



'Lodematic' lifter (see *opposite page*).



STRESS RELIEF

One of 12 heat exchangers for Bradwell Nuclear Power Station being stress relieved by Head Wrightson Teesdale Ltd. at their Thornaby-on-Tees works. The operation was carried out by insulating the vessels with Stillite *mineral-wool mattresses and semi-rigid slabs, supplied by Stillite Products Ltd. A stress-relieving temperature of 600 to 650°C. was achieved using internally suspended electric heating elements.*

When size or position rules out the conventional furnace this new technique offers an efficient and economical method, temperature being quickly attained owing to the low heat loss through the insulation. **CPE 1330**

water and solids discharge to the recirculating tank.

The deflector cone and entrainment baffle are adjustable. The purpose of the baffle is to arrest droplets that would otherwise be carried out by the gas.

The collector is painted with a heat- and corrosion-resistant protective coating. It is manufactured by W. C. Holmes & Co. Ltd. **CPE 1329**

Mass spectrometer

A mass spectrometer by Metropolitan-Vickers Electrical Co. Ltd. has been designed specifically for measuring minute impurities in solid substances using the spark ionisation technique.

Materials successfully analysed down to 0.01 p.p.m. include uranium, reactor-grade graphite, germanium, selenium, silicon, gallium-arsenide, magnesium, titanium, tungsten, iron, copper, aluminium, tin and nickel-chromium alloys.

The type MS7 is a double-focusing instrument of the Mattauch type in which positive ions, representative of the sample composition, are produced when a high-voltage spark occurs between two electrodes of the sample material placed close together in vacuum. After passing first through an electrostatic analyser and then through a magnetic analyser the ions come to focus according to their mass, but irrespective of their initial energy, as a series of lines on a photographic plate. **CPE 1331**

Cuts down plastics waste

Two new cutting mills, produced in Germany, are particularly suitable for the re-processing of thermoplastic waste and rejects during actual production run and can be mounted directly beside the injection moulding machine. In both models, the housing, a monoblock casting, is flange-mounted on the motor.

By taking off four fixing screws, the complete housing can be drawn off, making the rotor and all other parts freely accessible. Easily interchangeable screens for different grain sizes enclose the lower section of the mill in a semicircle. The smooth interaction of moving and fixed blades, set at a special cutting angle, ensures a clean-cut granulate without burrs or tails.

The hoppers can accommodate large awkward pieces. Baffles in offset arrangements prevent spilling. The makers are Condux-Werk Herbert A. Merges KG. **CPE 1332**

Test-tubes go for a spin

Four electrically driven laboratory centrifuges for 5 and 15-ml. tubes have been introduced, giving four speeds with a maximum of approximately 5,000 r.p.m. They have a four or six-place angle head which, according to the makers, Camlab (Glass) Ltd., makes it almost impossible to spill the specimen. The motor is cushioned and the spindle is self-centring, making careful balancing unnecessary. The price range is from £15 15s. to £17 17s. **CPE 1333**

Counts as it lifts

The telescopic, hydraulic, electric or petrol-driven *Lodematic* lifter can be fitted with tipping bin attachment or forks platform. It pushes like a sack truck when telescoped and different models raise to heights of 5 to 12 ft. It lifts, lowers and stops by single fingertip control and can be halted at any height. There is a device which counts as the machine lifts. **CPE 1334**

From tea to coal

An electrical unit, which takes advantage of the fact that pressure changes within a bulk container (or a discharger chute) are ready-made indicators of the state of replenishment, can be used to stop and start replenishing or extracting conveyors, to select alternative channels when replenishing feed hoppers of processing machines or when fuelling boilers, etc.

Bolted to the side of a container, the *Tidal* unit is sensitive to pressure changes through its flexible diaphragm. Movement of the diaphragm operates a single-pole, double-throw microswitch which has three contacts, two fixed, one movable which alternately contacts either of the two fixed. Pressure in the diaphragm opens one circuit and closes another; release of pressure returns the switching to normal.

The required degree of sensitivity normally varies in proportion to the weight of the materials and units are available from Redler Conveyors Ltd. with diaphragms suitable for anything from tea to coal. **CPE 1335**

Amphibious offloader

Substitution of a fork-lift attachment and wadeproofing converts a four-wheel-drive, rubber-tyred tractor shovel into a highly manoeuvrable loading and offloading machine. It can lift 4,000 lb. and has a travel speed of 27 m.p.h. In a recent demon-

stration it was offloading a vessel through 6 ft. of tidal water, and it will run straight on to the foreshore to convey the crates inland at the speed of a truck.

The makers, Michigan (Great Britain) Ltd., feel that this development will be welcomed in many parts of the world where port installations do not exist. **CPE 1336**

Spray comes out even

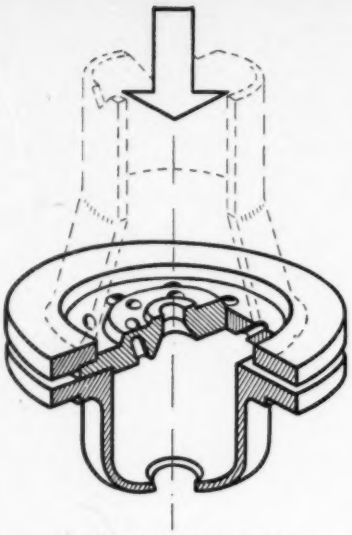
The *Hesky* nozzle, designed to provide uniform distribution of large quantities of liquids under low pressure, can be used in absorption, rectification and distillation columns, washing and cooling towers, coke quenching, etc. The distributing ducts of the nozzle plate are arranged in concentric circles. The average diameter of the drops, depending on the size of the nozzle and the starting pressure, lies between about 0.02 and 0.16 in.

The nozzle can have dispersion angles of 70° and 45°, the normal angle being 90°. For the most uniform distribution, the liquid should be under a pressure of about 12 p.s.i. and the minimum pressure is 4 p.s.i. Uniform distribution is given over a circular area up to a diameter of 16.4 ft. despite fluctuations of load within the permissible pressure range. For large tower diameters the sprayer may be installed so that it sprays upwards from below. The sprayers are available from Ascog Ltd. **CPE 1337**

Drum tap

A drip-proof and reversible drum tap which can be used with virtually any liquids, including paraffin, trichlorethylene, turpentine and others difficult to handle, is being marketed by Phillips Telescopic Taps Ltd.

The tap, moulded in *Rigidex* high-density polythene, has no internal



Details of 'Hesky' nozzle.

washers or glands and manipulation is by push-button control giving immediate on-and-off action. With a 1-gal. head of paraffin the tap delivers 1 pint of filtered liquid in 10 sec. **CPE 1338**

Wall-mounted air conditioner

An aerosol-turbo air-conditioning unit which supplies recirculated or fresh air at 1,500 cu.ft./min. and introduces a flow of minute aerosols is produced by P. M. Walker & Co. (Halifax) Ltd.

All air passing through the wall-mounted unit is washed and cleansed before entering the room as oversaturated air. This washing process also cools the air and a heater battery is available. The unit is flameproof for group 2 and group 3 gases. The machine maintains an overall even humidity for a volume of up to 50,000 cu. ft. and it is guaranteed non-wetting. It is automatic, maintains pre-set humidity within $\pm 2\%$, and is self-cleaning, the only maintenance likely to be required being the occasional cleaning or replacement of the filter in the reservoir tank. All working parts are made of stainless steel or special aluminium alloy. **CPE 1339**

Polythene discs save paint

A firm of paint manufacturers is using special discs of polythene to cover the contents of change-cans or tanks during production, so preventing the formation of skin on the surface. As much as half a gallon of paint can be wasted each time skin forms in this kind of operation, and removal of the skin with its associated dust is a troublesome operation.

The discs, supplied by E. S. & A. Robinson Ltd., are made to fit closely to the tank interior and can be placed in position in a matter of seconds. **CPE 1340**

Variable-speed drives

Simplicity of control and infinite variation are aimed at in the *Sextet* range of variable-speed drives for use with standard electric motors. Many new features have been introduced: splines replace keys and provide 360° of drive engagement between the flanges.

Variable loading is controlled by the adjusting ring setting the spring pressure to suit the particular application of each individual pulley. Maximum shaft sizes which are accommodated in each range ensure they can be used on all standard motors without resorting to turning down of motor shafts and the smallest size of pulley can be employed for the application. They are supplied by Industrial Drives Ltd. **CPE 1341**

American Developments in Brief

Self-contained, fully automated liquid nitrogen generator, made by Philips Electronics Inc., is capable of producing ultra-pure nitrogen from atmospheric air. **CPE 1342**

Long-life heating element of new design and *Pyroceram* end plates are used in a new furnace for general use in micro and semi-micro combustions at temperatures up to 1,150°C. The furnace, by Arthur H. Thomas Co., has a built-in platinum-platinum 13% rhodium thermocouple. **CPE 1343**

Useful for air pollution studies and gas diffusion analysis, the Gelman-Gill rapid-response bivane is an instrument designed for the accurate measurement of vertical and horizontal wind components. A permanent record is obtained on a companion recorder. Gelman Instrument Co. are the suppliers. **CPE 1344**

Specific gravity indicator which incorporates a float-type hydrometer and a thermometer is offered by Schutte & Koerting Co. It can be applied to measure specific gravities of liquids in systems at temperatures above their atmospheric boiling points. **CPE 1345**

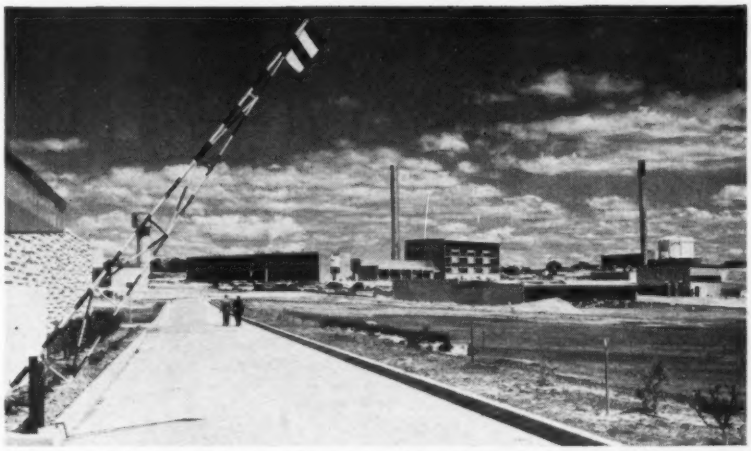
New nuclear instrumentation system useful in proportional counting, ionisation and fission chambers, etc., combines, on a single chassis, a basic non-overload amplifier and a highly regulated low-voltage power supply with a differential discriminator. A pre-amplifier is also available as an adjunct to this system produced by Hamner Electronics Co. Inc. **CPE 1346**

Nuclear Energy in Australia

By Professor J. P. Baxter
(*Vice-Chancellor, University of New South Wales*)

With no immediate need for nuclear power, Australia is building up an organisation which will investigate reactors most suitable for the local conditions. Prof. Baxter discusses the work of the Australian Atomic Energy Commission and its Research Establishment, and the contribution of Australian universities.

THE Australian atomic energy programme is a blend of effort by Government, industry (principally in mining) and the universities. Australian interest began in the post-war years when an urgent need for uranium first arose. As a result of exploration and discovery, fostered by governments, production of uranium oxide started at Rum Jungle in the Northern Territory in 1954, and shortly afterwards oxide was also being produced at Radium Hill in South Australia. More recently the Mary Kathleen deposits—the largest so far discovered in Australia — and the smaller deposits of the South Alligator River area in the Northern Territory have been developed. By the end of 1959 total production will be at the rate of about 1,100 short tons of oxide a year, of which some 650 tons will be from Mary Kathleen.



This view of the Australian A.E.C. Research Establishment at Lucas Heights shows the chemistry/chemical engineering laboratories (*centre*), **the 'Hifar' reactor and associated buildings** (*right*) **and the administrative offices and library** (*left*).

Research into ore treatment

Much effort has been applied to developing economic methods of treating uranium ores, which occur in great variety in Australia. A notable success is expected from the Weiss-Swinton resin-in-pulp process, developed by the Division of Industrial Chemistry of the Commonwealth Scientific and Industrial Research Organisation to overcome difficulties encountered in treating one of the Rum Jungle ores: this process is now being tested on a full scale. Other research is being carried out by the South Australian Department of Mines and in the universities.

The Atomic Energy Commission

The Australian Atomic Energy Commission, a Government corporation established in 1953, has two main interrelated fields of activity: (*a*) the discovery and production of uranium and (*b*) the development of industrial and other applications for atomic energy. For (*b*) the Commission is authorised, in comprehensive terms, to develop the practical uses of atomic energy; to construct and operate plant for this purpose; and to undertake, organise and generally encourage scientific research with a view to the advancement of nuclear technology. The Commission conducts its own research, fosters research by the universities in appropriate fields, and exchanges scientific and technical information with similar bodies in other countries.

As a small nation with limited resources, Australia attaches particular importance to international co-operation. Under an arrangement with the United Kingdom, the Commission's research staff began work on the Australian programme at Harwell, pending the construction of the Commission's own research establishment near Sydney. This co-operation continues under a bilateral agreement with the United Kingdom. Another important agreement was concluded in 1956 with the United States—one of the first bilateral agreements covering power reactors and fuel to be made by the U.S. with the smaller countries. A co-operation agreement has also been negotiated with Canada and is expected to be signed shortly and there have been close relations with other countries, such as France and South Africa. Australia took an active part in the negotiations leading to the International Atomic Energy Agency and has been a member of the Board of Governors since its inception.

Lucas Heights research centre

The Commission's research establishment at Lucas Heights, near Sydney, was officially opened in April 1958.

The research reactor *Hifar*, similar to *Dido* at Harwell, was built with the help of drawings and design information generously supplied by the United Kingdom. Head Wrightson Processes Pty. Ltd. were the contractors and *Hifar* reached criticality on January 26, 1958. It has been operated at low power during an initial period of running in and testing of instrumentation, but has already been used for some small-scale test work and for the trial production of radioactive isotopes. The associated buildings include accommodation for post-irradiation cells, equipment for handling and cropping fuel elements, etc.

A chemistry/chemical engineering building, comprising a 47,000 sq. ft. area, houses the analytical services group and the chemistry chemical engineering sections. It includes a

range of ' hot ' laboratories and special equipment for handling radioactive materials.

A large metallurgy fabrication bay, now complete, will form part of a large metallurgy engineering building under construction. In addition, there are a number of special purpose buildings and laboratories and various special services.

Research programme

The research programme centres on the development of a high-temperature gas-cooled reactor suitable for Australian needs and conditions. At present effort is being concentrated on small-scale sorting experiments related to fuel systems, and the development of equipment for a larger-scale examination of the two or three most promising systems. Detailed reactor design will not be attempted until the preliminary experimental programme is well under way.

Fuel-element research will cover loop experiments, chemistry and compatibility studies, research on processing problems, as well as general theoretical and design studies, to solve problems of stability, control, possible burn-up and overall economy. Through the work at Lucas Heights it is hoped to develop a ' self-breeding ' fuel—incorporating thorium so that fissioned uranium is continuously replaced by Uranium-233—which will reach a high ' burn-up.' A suitable fuel would have fissile and fertile materials dispersed in the moderator so as to disperse the heat source and thus provide high ratings.

Beryllium and beryllium oxide are being studied actively as moderator materials and fuel carriers, but as fuel elements containing graphite are of interest because of graphite's high-temperature strength, a small amount of effort is being devoted to this. Studies on beryllium metal fabrication are limited by the present facilities, but new beryllium laboratories are being completed. At present powder metallurgy techniques are employed to make small samples. Fuel samples using beryllium metal containing both uranium and thorium have been made and a detailed study of various intermetallic compounds is in progress, while the oxide systems of beryllium, uranium and thorium are also being studied in detail. Irradiation of beryllium in *Hifar* will be undertaken to determine mechanical properties under the effects of high neutron fluxes.

Work on graphite involves fabrication of fuel materials containing high

Officials of United Uranium N.L. examine large blocks of pitchblende; the central specimen weighs 1,875 lb.

percentages of uranium and thorium carbides; for this the basic chemistry of the carbides is being investigated. Another problem is the production of graphite, impermeable to fission product gases; several methods of sealing are being studied.

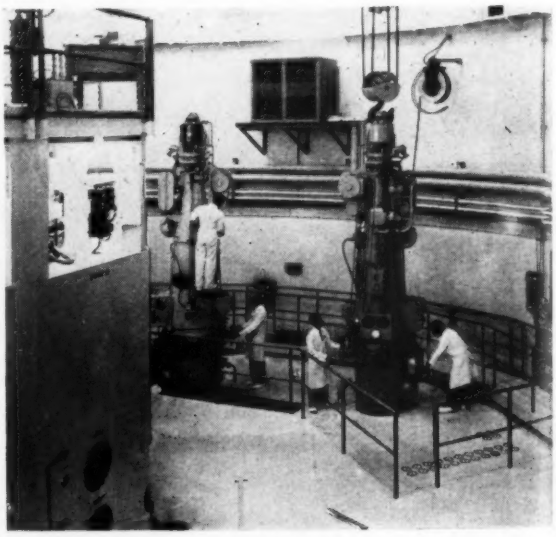
Research on a sodium-based, liquid metal fuel reactor was begun at Harwell in England and has continued on a limited scale at Lucas Heights. A certain amount of critical information is still required in the fields of metallurgy, chemical engineering and chemistry before studies on the physics and engineering aspects can lead to a reactor design. The principal problems are the compatibility of moderator and structural materials with a sodium uranium fuel, and the behaviour and dispersion of heavy particles in a light liquid under dynamic conditions. A sodium plant designed to pump molten sodium at 500°C. at 10 gal./min. is being used for research of compatibility problems, for testing various components, checking heat-transfer data, and for training staff in handling liquid metals.

Chemical processing

A chemical processing group in Australia is collecting information on fuel processes developed overseas and investigating some processing methods. The treatment and disposal of radioactive effluents, which may come either from research activities at Lucas Heights or from chemical processing plants, is being studied, while various chemical engineering problems which may arise in nuclear fuel processing are being examined with a view to the later construction of any processing plant Australia may require. The feasibility of processing *Hifar* fuel locally is also being considered. It is a long-term aim of the group to build up experienced staff, which would allow Australia to be self-supporting in the recovery and recycling of nuclear fuel for her own power programme.

Isotopes

An isotopes advisory section forms an important part of the Lucas Heights activities. Advice is given to industrial and other isotope users, investigations are made on specific applications, and some research is carried out. Although there is great scope for the application of isotopes in a wide range of industrial processes,



Technicians working on the fuel-element handling flasks of the ' Hifar ' reactor. Irradiated elements are stored in holes in the concrete floor for a suitable decay period.

Adjusting equipment in a glove box at the Lucas Heights centre.

Australian industry has been somewhat slow to make use of them. However, interest is growing steadily and a substantial demand should develop for various forms of gauges and equipment.

Isotopes will be produced in *Hifar*, particularly short-lived materials which are difficult or impossible to obtain from abroad because of the time factor. In addition, it is planned to produce Cobalt-60, for which there is a fairly large demand in Australia for medical and industrial purposes.

Research in the universities

To give Australian universities access to the specialised facilities of the Research Establishment for training and research, a joint organisation known as the Australian Institute of Nuclear Science and Engineering has been formed. The Institute is governed by a council composed of Commission and university representatives and has a small permanent secretariat. Through the secretariat and in association with the Commission, the council organises research fellowships and training courses for university staff and students, and also assists, on request, in the organisation of courses within the universities themselves. The Commission is providing a headquarters building for the Institute at Lucas Heights and is contributing up to £50,000 p.a. towards the cost of research programmes and training courses. Administrative costs will be shared.

Some 30 separate research projects are being undertaken in Australian universities with funds provided by the Commission. They deal with a variety of aspects of nuclear science and engineering, ranging from problems in the extraction of source materials from the ores to construction of a variable energy cyclotron and research in neutron physics.

Applications of nuclear power

Electric power in Australia is generated and distributed through a large number of separate systems varying in size from over 1,000 Mw. down to a few hundred kilowatts. The main generating systems, which produce about 90% of the country's total output, are operated by State Government instrumentalities and most towns with any appreciable power demand are connected to one of these systems. In general, the smaller isolated systems are much too small to benefit from nuclear power within the foreseeable future, the main exceptions being Darwin and the mining towns of Mount Isa, Broken Hill and Kalgoorlie.

However, although there is no immediate call for nuclear power in Australia, it is almost certain that there will be a considerable demand in the not-too-distant future, and Governments and industry must plan accordingly.

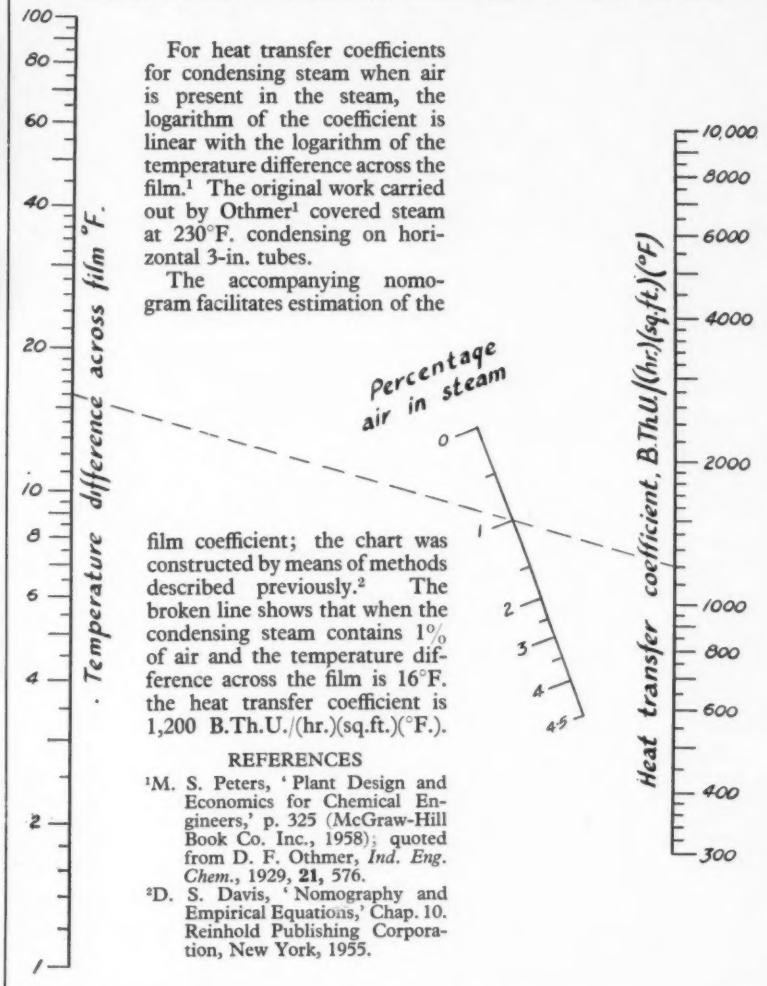
Heat Transfer Coefficients for Condensing Steam

By D. S. Davis

(*Head, Department of Pulp and Paper Technology, University of Alabama*)

For heat transfer coefficients for condensing steam when air is present in the steam, the logarithm of the coefficient is linear with the logarithm of the temperature difference across the film.[1] The original work carried out by Othmer[1] covered steam at 230°F. condensing on horizontal 3-in. tubes.

The accompanying nomogram facilitates estimation of the film coefficient; the chart was constructed by means of methods described previously.[2] The broken line shows that when the condensing steam contains 1% of air and the temperature difference across the film is 16°F. the heat transfer coefficient is 1,200 B.Th.U./(hr.)(sq.ft.)(°F.).



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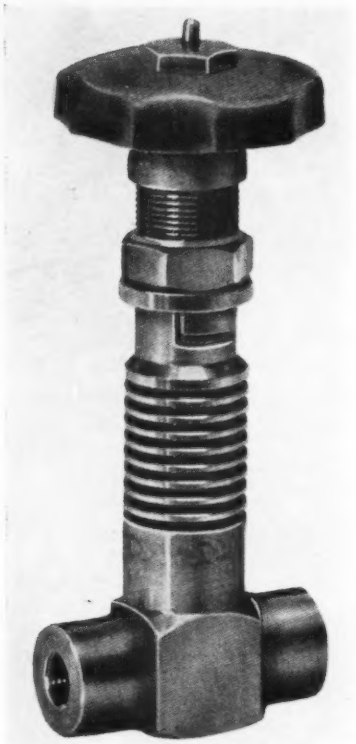
[1] M. S. Peters, 'Plant Design and Economics for Chemical Engineers,' p. 325 (McGraw-Hill Book Co. Inc., 1958); quoted from D. F. Othmer, *Ind. Eng. Chem.*, 1929, **21**, 576.

[2] D. S. Davis, 'Nomography and Empirical Equations,' Chap. 10. Reinhold Publishing Corporation, New York, 1955.

Chemical Plant on Show in France

A 'COUP D'OIEL' AT THE SALON DE LA CHIMIE

THE 5th Salon International de la Chimie, held in Paris recently, provided an opportunity of seeing the latest products of the French chemical, plastics, rubber and petroleum industries and also the plant, equipment, instruments, raw materials, etc., by which they are served. While there were interesting improvements and modifications in many of the items displayed, the exhibition yielded little in the way of completely new designs, processes or materials, and perhaps the most notable feature was the obvious effort that has been made by the manufacturers of automatic controls and instruments to meet the increasingly complex requirements of modern industrial operations, particularly in applications involving high temperatures and pressures or the handling of corrosive or dangerous materials. There was considerable evidence, too, of the increased use of special steels and alloys for chemical plant, while the variety of ways in which plastics, rubber, graphite, ceramics and other non-metals are being used in conjunction with metals (e.g. *as linings or reinforcement*) *was also impressively demonstrated. The following review is mainly devoted to some of the interesting chemical engineering exhibits.*



Straight-through valve, type 511-50, one of a range shown by Appareils Gachot.

Two new items displayed by Société le Carbone-Lorraine were the *Polybloc Super* **heat exchanger** and the *Polybloc* 'trumpet-hole' **absorber.** The latter has, as its basic element, a cylindrical graphite block with a hole through the centre and radial and axial passages. A number of such blocks is assembled into a column in the same way as the *Polybloc* heat exchangers. One example of its use is the countercurrent absorption of HCl gas in water to produce concentrated hydrochloric acid. The construction of the unit is such that the absorbing water forms an even film as it travels down through the absorber, and this film is continuously regenerated. The gas to be absorbed passes upwards from the bottom, through the distributing channels, and on passing through the conical sections of the passages it becomes compressed and increases its velocity.

The *Polybloc Super* heat exchanger can accommodate heat-transfer areas of up to 600 sq. ft. in a single unit. One model has process passages of 10 mm. diam. while another has passages of 18 mm.

Appareils Gachot showed a considerable variety of stainless-steel **valves and cocks,** pipe fittings, flow indicators and stainless-steel tube as well as bolts and screws. Another side of this versatile company's activities is shown in its range of items in *Gaflon* **PTFE,** including gaskets, sealing rings and *Dilatef* bellows. These last are used either for connecting tubes of different materials which are out of line or which meet at an angle, or for absorbing expansion or vibration in installations subjected to changes of temperature or made in fragile materials such as glass.

For laboratories handling highly corrosive liquids there is a straightway needle-valve in which all parts in contact with the fluid are in PTFE, the remainder being in 18/8 Mo stainless steel. Also for use in laboratory glass-piping systems is a range of *Gaflon* miniature cocks which are simple to fit and to manipulate. A filtration cloth in *Gaflon* is also offered for the industrial filtration of corrosive liquids. It has been successfully tested for 24 hr. in a number of boiling solvents.

The range of **colloid mills** displayed by René & Jean Moritz (associates of the Moritz Chemical Engineering Co. Ltd., London) included the laboratory finishing mills BF50 and BF60, in which the shearing action has been particularly developed in order to increase efficiency. There is a device for adjusting clearance between milling faces and a micro-metric adjusting device with graduated scales to regulate distance between rotor and stator. The BF50 is driven by a motor of approximately 1 h.p., suitably enclosed and operating on standard current at a speed of 3,000 r.p.m. with a push-button starter. The BF60 is provided with a $1\frac{3}{4}$-h.p. motor and will handle more viscous liquids.

V-mixers for powders and various laboratory machines for mixing, emulsification, dispersion and agitation were also shown.

The stand of O.N.I.A. (Office National Industriel de l'Azote) gave information on the company's research programme and on the **processes** it has developed in recent years. These include two commercial processes for the conversion of gaseous or liquid hydrocarbons into an extensive range of products, including synthesis gas for the chemical industry and town's gas for domestic consumption. More than 110 O.N.I.A. (continuous catalytic conversion) and O.N.I.A.-G.E.G.I. plants are in operation throughout the world. O.N.I.A. has also developed or improved processes for the removal of sulphur from gases,

for compound fertiliser manufacture and for the production of ammonium sulphate from gypsum. A process for the direct reduction of iron ore in a fluidised bed has also been developed.

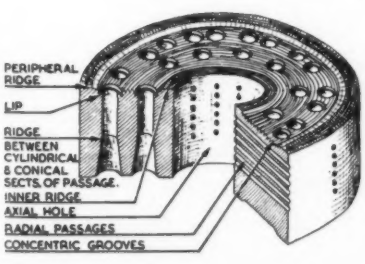
The first butyl **synthetic rubber** to be made in France, *Socabutyl*, was featured on the stand of Société du Caoutchouc Butyl, whose 20,000-tons-p.a. plant at Le Havre was brought into operation earlier this year. *Socabutyl* is claimed to have an impermeability to gases some 10 or 12 times greater than that of natural rubber, and excellent resistance to ageing. It also has excellent heat resistance and stands up well to a number of chemicals.

Four I.C.I. Divisions had stands at the Salon. Two products on show by the Plastics Division were *Fluon* PTFE and *Butakon* butadiene copolymers. The latter materials range from rubber-like products to hard resins, and are also available as latices or aqueous dispersions. The Dyestuffs Division indicated some uses of polyurethane foams, which include removable pipe lagging, while the General Chemical Division made a feature of *Cereclor* chlorinated hydrocarbons and *Alloprene* chlorinated rubber, the latter being used to impart special properties to paints, adhesives, textile finishes and other surface coatings. The General Chemicals Division displayed alkylated phenols for use in the manufacture of detergents, textile auxiliaries, oil additives and varnishes, and also a range of plasticiser alcohols and the *Topanol* anti-oxidant. I.C.I. catalysts, made by Billingham Division at Clitheroe, were also featured.

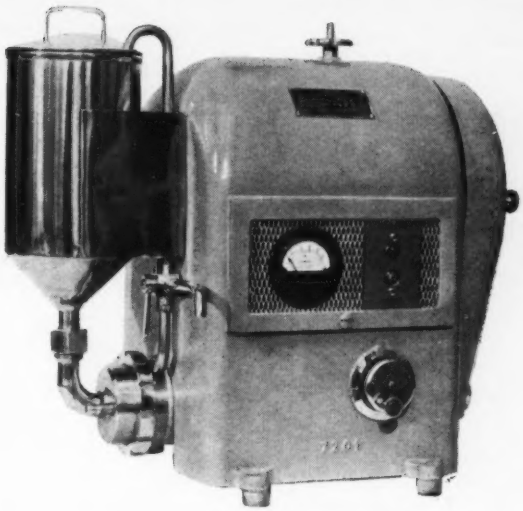
The stand of Staatsmijnen, the Netherlands State Mines, emphasised the activities of this organisation in selling know-how for both organic and inorganic **chemical processes,** for instance to the Italian firm, A.N.I.C. Milan, which is to take up the manufacture of urea based on the natural-gas resources of the Po valley. There were also displays connected with the products of Staatsmijnen, such as urea in uniform globular prills, organic starting materials for synthetic fibres and yarns, and also polythene. Staatsmijnen are at present making use of the I.C.I. high-pressure process, while the Ziegler low-pressure process is being operated on a pilot scale.

Pompes Celtiques featured apparatus for measuring low and very low pressures making use of a Pirani gauge associated with an ionisation gauge with a vacuum control device, the range of measurement being from 1 to 1.10^{-6} mm. of mercury.

Some interesting items of **silica** ware were featured on the stand of Quartz & Silice, who claim to be the first to make commercially practicable filaments of 99.99% fused silica. Fabric woven from these filaments can be used as reinforcement for plastics submitted to high temperatures.



Details of graphite absorber unit shown by Société Carbone-Lorraine



Labo-finishing mill shown by Moritz.

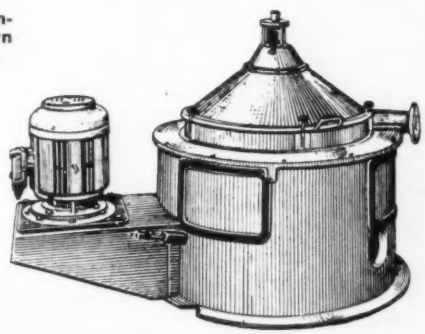
A range of three vertical **pumps,** type ' L,' of capacities between 20 and 60 cu.m./hr., were shown by Appareils & Evaporateurs Kestner in various materials including lead, stainless steel and *Keebush*. Amongst other equipment on the stand was a ' salt pump,' representing a new method of pressure-refining solid salt (rock or sea salt) which utilises the variation in solubility of constituents of crude salt with temperature to effect the separation of impurities (particularly sulphates) without using special reagents.

The variety of special horizontal and vertical **pumps** displayed by Société Nouvelle Klein in collaboration with the German firm of Rheinhütte included a new centrifugal, self-priming, vertical-shaft model for the chemical industry, while there were also valves for water and steam in cast iron or steel.

New items shown by Lamy included the Nauta-Combimiser **powder mixer** with two connected mixing chambers, permitting continuous mixing with low power consumption; and ' geared ' metering pumps without stuffing boxes and resistant to very high temperatures. Acid pumps fitted with mechanical seals were also shown.

Four **centrifugal extractors** were shown on the stand of Les Constructions Guinard, these being designed for the extraction of granular or crystalline solids which are present in suspension in a liquid. They are made in

One of the centrifuges shown by Guinard.



a variety of metals and alloys, according to the material to be treated. The centrifuge basket is in the form of a truncated cone. These machines, for continuous operation, are stated to have low power requirements.

A number of *Paraflow* plate-type **heat exchangers** were shown by Société A.P.V., including the new models HXL-4, IHMB and CHF. The plate-type evaporator which recently made its début in Britain was also shown, as were Manton-Gaulin homogenisers.

Ets. Bignier Schmid-Laurent had on show a large **expansion joint,** able to resist pressure without excessive strain on the metal and permitting considerable expansion. A notable application is the large pipeline for heavy water serving the EL3 nuclear reactor at Saclay.

A new type of **separator** shown on the stand of Brissonneau & Lotz was the *Sedeco*, a centrifugal machine capable of continuous working without clogging, and with applications in the chemical, food, pulp and paper, oils and fats, and many other fields. Refrigeration equipment was also exhibited.

S.E.P.I. showed a *Zallea* **expansion joint,** constructed in France and destined for the main cooling circuit of the EDF 1 nuclear reactor, Chinon. With a nominal diameter of 1.4 m. and weighing 3 metric tons it is designed to work at a pressure of 28 kg./sq.cm. and a temperature of 380°C.

A section of a **tunnel kiln** was shown by S.A.N.E.G. The kiln is equipped with radiant panels, these being positioned in the lower part of the kiln and arranged at a particular angle. The upper section carries reflectors of polished aluminium. The burnt gases are collected and led through an enclosed pipe system to the stack while the solvents and vapours produced in the process are drawn off through separate passages. The whole installation is heat-insulated and is designed to make efficient use of both radiant and convectional heat.

ORDERS and CONTRACTS

The licensees in Japan of the Power-Gas Corporation Ltd., Stockton-on-Tees, Mitsubishi Chemical Machinery Manufacturing Co. Ltd. of Tokyo, have received an order for one unit of carburetted water-gas plant, with a capacity of 2 million cu.ft./day, for the Saibu Gas Co. Four units each of similar capacity have previously been installed for the same company. Mitsubishi have also received contracts for four gas-producer units, each 10 ft. 6 in. in diam., and for a CO conversion plant for Toho Gas Co.

Since 1954 the Power-Gas licensees in Japan have received orders for C.W.G. units with a total daily productive capacity of 118 million cu. ft.

*

Overseas orders totalling almost £140,000 are announced by Fawcett, Preston & Co. Biggest of them is for nine pulp-steeping presses and two fibre-baling presses which will be incorporated in the rayon plant which Courtaulds Ltd. are building for Russia.

Each of the steeping presses will weigh about 30 tons and will be 56 ft. long. Pumping equipment will be supplied by Towler Bros. (Patents) Ltd. The other orders comprise extrusion machinery for Pirelli of Naples, Nordiske Kabel Fabrieken of Copenhagen and the Holland Insulated Wire & Cable Co. of Amsterdam.

*

Blaw Knox Chemical Engineering Co. Ltd. has been awarded a contract by Petrolite Ltd. for a plant to be erected at Liverpool. Products will include demulsifiers, de-salting chemicals, corrosion inhibitors and paraffin solvents. The plant is scheduled for completion by the end of this year.

*

Vitro Engineering Co., a division of Vitro Corporation of America, has been awarded a $4.3-million contract by the Atomic Energy Commission to design and engineer a new facility at the Hanford works for the processing of commercial power reactor fuels. Planned for operation in early 1961, it will reprocess from 50 to 150 tons p.a. of fuel element materials (up to 5% U^{235}). It will be capable of handling fuel elements of all designs and shapes including oxide and alloy cores clad with aluminium, zirconium and stainless steel. Elements will be received in shielded casks, stored in a water environment, dismantled mechanically and chemically treated in preparation for processing by solvent extraction in existing redox facilities which were originally designed by Vitro for the A.E.C. in 1949.

*

A contract of approximately £2½ million has been awarded to Constructors John Brown Ltd. for a sugar factory at Kavar in Iran, for the Sherkat Shami Ghande Pars Co. Associated with C.J.B. for the project is A. F. Craig & Co. who will supply equipment capable of processing 1,000 tons/day of sugar beet, with allowance for eventual expansion to 1,500 tons/day. The factory is due for completion by early 1961.

*

The U.S.-Euratom Joint Research and Development Board has awarded contracts amounting to some $315,000 to: American Standard Corporation, for clad ceramic plate fuel elements by spray-coating techniques; Battelle Memorial Institute, for boiling heat-transfer and void distribution studies with water coolants; and Compagnie Industrielle des Ceramiques Electroniques, for a study project on the extrusion of uranium dioxide.

These contracts are the first to be negotiated under the joint programme.

*

The Clyde Alloy Steel Co. Ltd. has placed a contract with the Kestner Evaporator & Engineering Co. Ltd. for an acid pickling plant to treat 620 tons/week of steel billets and castings. The contract will also include a Kestner/Fakler acid recovery unit, a continuous neutraliser and fume extraction plant.

The pickling plant will comprise two tanks, 17 ft. 6 in. × 8 ft. × 5 ft. deep, one of which will contain sulphuric pickle acid, and the other wash water. Heating of the pickle acid will be by circulation through an acid heater; this circulation system will also cause continuous movement of the pickle acid along the pickle tank. Fume extraction is by a 36 in. fan through lip ducts on the pickle tank. All acid-contacting materials will be *Keebush* and *Keeglas*.

*

A large order for machinery equipment for a cellulose mill has been signed between Karlstads Mekaniska Werkstad and the Soviet purchasing agency, Techmashinimport, according to Swedish Press reports. The mill will have a capacity of 200,000 tons p.a. of prehydrolysed sulphate viscose pulp.

The machinery is to be supplied by K.M.W. and a number of other Swedish industries.

New Urea Project in U.S.A.

The big new fertiliser plant now under construction in the state of Delaware will be equipped for the complete conversion of ammonia and carbon dioxide to urea, which it will produce in both prilled and crystalline form. The project is a good example of economical design using a scale model.

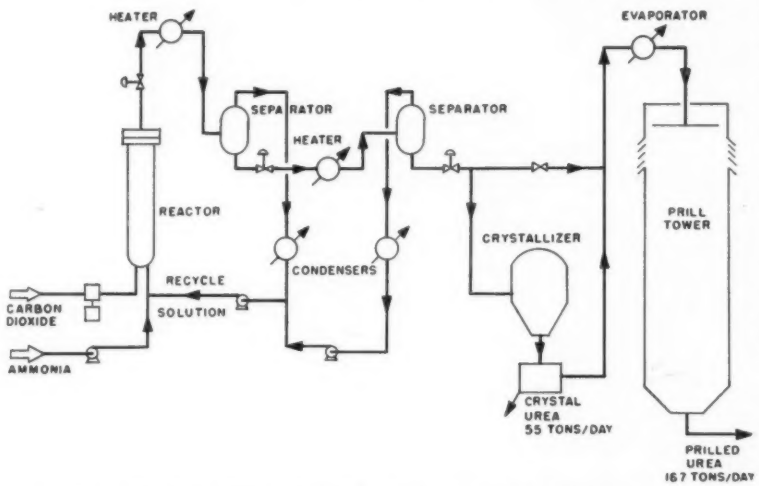
CONSTRUCTION of the East Coast's first major urea plant, representing an $8-million joint venture of Sun Oil Co. and Olin Mathieson Chemical Corporation, began at North Claymont, Del., U.S.A., recently. Scheduled for completion early next spring, it will produce 73,000 tons p.a. It also will produce some 10 million cu. ft. of hydrogen to be used by Sun Oil to produce ammonia and for other refining processes.

Daily raw materials requirements include 120 tons of ammonia from Sun's refinery at Marcus Hook, Pa., 150 tons of carbon dioxide to be produced by SunOlin's steam methane reformer and 9 million cu. ft. of natural gas from Sun's gas fields in southwest Texas. The natural gas will be delivered *via* pipelines of the Transcontinental Gas Pipeline Corporation.

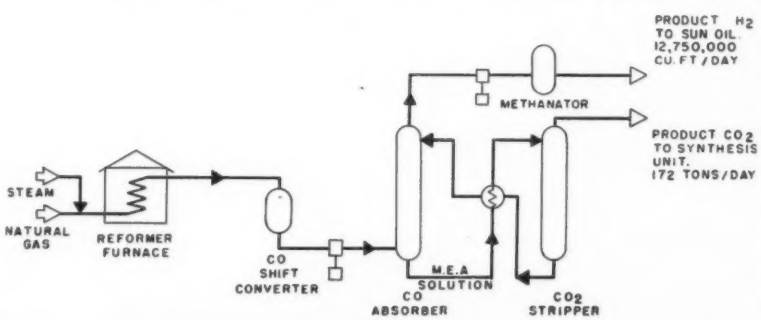
Five grades of urea will be produced. Prilled urea will be sold for fertiliser and industrial uses, and a special cattle-feed grade will be made, in addition to a high-purity crystalline product for leaf spray and industrial uses.

Ideally situated for supplying agricultural, dairy and beef-raising areas of the Eastern seaboard, the plant is also near many of the large industrial consumers of urea. The company also anticipates supplying the rice and cotton belts along the Gulf Coast and plantations of South America on a competitive basis.

The plant will use the Montecatini process, developed by the big Italian company of that name. In this process, liquid ammonia and carbon dioxide gas are reacted at 2,800-lb. pressure and at 370°F. to form ammonium carbamate, which then decomposes to urea and water.



Simplified flow diagram of synthesis section of the North Claymont plant.



Steam methane reformer.

Urea synthesis

In the urea synthesis section the production of 200 tons/day of urea is accomplished by converting liquid ammonia and gaseous carbon dioxide, the first step being compression to 2,800 p.s.i. Along with a recycled ammonia and carbon dioxide solution the compressed materials are fed to a reactor, where about half the feed is converted to urea and water. The balance of the stream from the reactor is an unstable compound, ammonium carbamate. Some of the water and the ammonium carbamate, which decomposes to ammonia and carbon dioxide, are condensed and returned to the reactor. By recycling ammonia and carbon dioxide, the overall conversion to urea is expected to be over 95%.

Urea is recovered from the stream coming from the reactor by reducing the pressure and applying heat. Any remaining water is evaporated under a vacuum and the resulting molten urea is prilled. In addition to making prills, some of the urea solution can be sent to a crystalliser, the resulting crystals being centrifuged to remove water before being dried and bagged.

Steam methane reformer

In the steam methane reformer carbon dioxide is produced by heating a mixture of steam and natural gas to about 1,500°F. in a furnace in the presence of a nickel catalyst. This yields hydrogen, carbon monoxide and carbon dioxide, which are then reduced in temperature to about 700°F. and passed over an iron oxide and chrome oxide catalyst which converts most of the carbon monoxide to carbon dioxide. Almost all the gas (essentially carbon dioxide and hydrogen) is charged to an absorber, where the carbon dioxide is dissolved in a solution of monoethanolamine. The carbon dioxide absorbed by the MEA solution is released by heating the solution and is charged to the urea synthesis section.

The hydrogen and final traces of carbon oxides are not absorbed in the MEA solution and go to a methanator. Here, in the presence of a nickel oxide catalyst, the carbon oxides are converted to methane. The resulting hydrogen containing a small amount of methane is sent to the Sun refinery for the manufacture of ammonia and other uses.

Scale model

The design of the urea plant was created directly on a model, scale ¾ in. : 1 ft., using a special technique developed by the contractors, M. W. Kellogg Co., to assemble the components.

A model such as this would cost approximately $30,000 if independently built by a model maker from drawings; however, in this case the cost to SunOlin was nil. Since the model was used as an engineering tool, it reduced rather than added to the cost of the project.

In design models of this sort some 80 plastic components are used, assembly being made quick and easy through a 'push-fit' technique. Because each pipe run or each exchanger bank is visualised in advance as it will actually appear in the completed plant and in its proper relation to all other elements, optimum arrangements are quickly made. Changes which would be costly to make in the field take but a moment on the model.

This scheme has proved so successful that full planning studies and piping key plans have been eliminated. Isometrics are drawn directly from the model and used for detailed fabrication sketches of all piping. As well as eliminating the cost of drawings, the model saved time for SunOlin's management and engineers. Reviews at different stages were made using the model as a reference, because it is such an unequalled communications tool.

The model will be sent to the urea plant site at North Claymont and will be used as a reference tool during construction. It will also be used to orient and train plant operators and will add greatly to the ease with which maintenance, repairs and changes can be effected during plant operation.

£ s d

CHEMICAL PLANT COSTS

Cost indices for the month of July 1959 are as follows:

Plant Construction Index: 177.7

Equipment Cost Index: 165.0

(June 1949 = 100)

£ s d

Company News

Richard Klinger are opening a new £100,000 factory at Perth, Western Australia, where production of *Klingerit* compressed-asbestos sheet jointing and cut gaskets will start at the end of this year. Later on the company plans to manufacture a number of other Klinger engineering products there.

Covering 25,000 sq. ft., the factory incorporates many new building techniques and many of the special machines are to Klinger's own design.

The company already has manufacturing plant working at top pressure in Austria, Great Britain and Germany.

★

Formation of a new international company to design, engineer and build petroleum refineries and chemical plants has been announced by Arthur G. McKee & Co., U.S.A., and Head Wrightson & Co. Ltd., England. The new concern, McKee Head Wrightson, will be a British company with headquarters in London.

★

The Power-Gas Corporation Ltd., Stockton-on-Tees, has recently installed an oil gasification plant for the South-Eastern Gas Board at the Isle of Grain. The plant consists of four Segas units with a potential capacity of 20 million cu.ft./day.

Similar plants, of smaller capacities, have been supplied by the company to other parts of the U.K., as well as abroad in West Germany, Sweden, Switzerland, Italy, Malta and Hong Kong.

★

Woodall-Duckham Ltd. has acquired the whole of the share capital of Nordac Ltd. by the issue to Nordac shareholders of 185,189 ordinary shares of 5s. each in Woodall-Duckham.

Nordac carries on a chemical engineering business and specialises in submerged-combustion equipment. The company also carries on an extensive business in anti-corrosion lining of chemical plant at its works at Uxbridge.

Nordac will continue to operate as a separate company within the Woodall-Duckham Group.

★

B.T.R. Industries Ltd. are to act as U.K. representatives of Gewerkschaft Keramchemie, Germany, in the design, supply and erection of chemical- and corrosion-resisting plant and equipment. A joint design office is to be set up in London. Linings, coatings and equipment of rubber, plastics, etc., will be offered as well as ceramic products and acid-resisting bricks.

★

Cory Bros. & Co. Ltd., a member of the Powell Duffryn Group, has acquired the share capital of MacCleaster Chemical Co. Ltd. MacCleaster, a private company formed four years ago, manufactures anti-corrosion compositions for the protection of metals. It is intended to expand the company's production facilities and to develop its present organisation to provide a comprehensive advisory service on industrial corrosion problems.

★

A new fertiliser company has been formed in Canada by Fisons Ltd., in association with Albatros Superfosfaatfabrieken N.V., of Utrecht, with whom all Fisons overseas fertiliser companies are jointly owned. The new company is Hy-Trous Co. of Canada 1959 Ltd., which takes over the assets and goodwill of a family fertiliser business, Hy-Trous Co. of Canada Ltd.

In the past the Hy-Trous factory on the St. Lawrence Seaway has mixed granular and powdered raw materials, but an immediate stepping up in the production of better fertilisers is planned. The new company is installing a granulating plant to come into production this season.

Fisons and Albatros already own one Canadian company, International Fertilizers Ltd., founded in 1930, with which Hy-Trous will be run in close co-operation. It operates granulating plants at St. John, New Brunswick, and Wolf's Cove, Quebec.

★

An agreement has been signed between the Société Nouvelle des Huiles Minérales, of France, and Rocol Ltd. for the manufacture of *Rocol* molybdenised and other specialised industrial and motoring lubricants in France and for their distribution throughout the European Common Market area.

A quarterly summary of recent happenings in the United States

The breathtaking advance of nuclear development is nowhere better exemplified than in the U.S. Atomic Energy Commission's latest plans to build a $24½-million gas-cooled reactor for central station generation of electricity. To be located in the same state where the big Shippingport pressurised-water reactor—hailed a short while ago as one of the most advanced concepts of reactor technology—is in operation, the plant is expected to be capable of operation at higher, more efficient temperatures than any other plant now operating or under construction.

Contracts have been signed with General Dynamics Corporation and the Philadelphia Electric Co. for development and operation of the plant. To be located in York County, Pennsylvania, and scheduled for completion in 1963, the plant will be designed to produce steam at 1,000°F. and pressures of 1,450 p.s.i. The 52 companies participating in the financing of the project comprise the largest and most widely representative group of utilities to support an atomic power project in the U.S. thus far.

The H.T.G.R.—high-temperature, gas-cooled reactor system—is designed to use graphite-clad, homogeneous fuel-moderator elements. The fuel elements contain a small proportion of enriched Uranium-235 and a larger amount of thorium mixed with graphite in homogeneous carbon compacts. The reactor is able to generate 1,000° steam, using compact reactor steam-plant equipment, because of the high temperature (around 1,380°F.) of the helium coolant from the reactor. These high coolant temperatures are possible because of the graphite-body fuel elements.

Among the characteristics of the H.T.G.R. system which hold promise a short cut to the goal of economic nuclear power are:

(1) Simplicity and compactness.
(2) Use of inexpensive construction materials which, together with high thermal efficiency, mean low capital costs, particularly in larger-size plants.
(3) High steam pressures and temperatures, permitting use of modern steam-turbine equipment.
(4) Low fuel cycle costs and long fuel burn-up, resulting in lowered operating costs.
(5) Good nuclear economy.
(6) A high degree of inherent safety.

The main development effort for the H.T.G.R. prototype calls for graphite-clad fuel elements. As a supporting programme, provision will be made whereby the fuel elements may be initially clad with metal to permit early operation and testing of the entire plant equipment. During the initial operation testing phase it will be possible to carry out a gradual transition to the graphite-clad fuel elements, because the reactor core is designed to accommodate these core changes.

$

The highest U.S. engineering award, for the first time in its 58-year history, will go to a man with a non-engineering background, for his vision and industrial leadership in the development of atomic power. The award is the John Fritz Medal and the man is Gwilym A. Price, chairman of Westinghouse Electric Corporation. The presentation will be made at the annual meeting of the American Society of Mechanical Engineers at Atlantic City in December.

Mr. Price, a lawyer by training, joined Westinghouse as vice-president in 1943, was elected president in 1946 and chairman in 1955. Within the Westinghouse organisation he formed the team which was responsible for the development of the atomic plant for the submarine *Nautilus*; this in turn led to America's first full-scale atomic power station at Shippingport.

The four national engineering societies responsible for the award are the American Society of Civil Engineers, the American Institute of Mining, Metallurgical and Petroleum Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. On October 1, the American Institute of Chemical Engineers becomes the fifth society to administer the award. Past recipients of the John Fritz Medal, established in 1902, include Lord Kelvin, George Westinghouse, Alexander Bell and George Edison.

$

An idea of what can be achieved by the use of fluidised-bed techniques of processing is afforded by some recent successes of Battelle Memorial Institute, which has given special attention to the adaptation of the fluidised bed to specific industrial operations. Thus a mining company was producing large tonnages of pyrrhotite containing about 1% nickel which was not being recovered by ordinary roasting and leaching procedures. Employing special techniques, a process for sulphate roasting was developed at Battelle which converted 95% of the nickel sulphide to a soluble sulphide. The process, developed in a 4-in.-diam. reactor, was piloted in a 2-ft.-diam. reactor and is now in operation in a 20-ft.-diam. fluidised-bed reactor in the sponsor's plant.

Some of the currently popular fluidised-bed processes for the direct reduction of iron ore are operated at temperatures too low to give complete reduction of the iron. Low temperatures and incomplete reduction have been necessary because of the tendency of the reduced iron to defluidise at

(*Concluded on page* 337)

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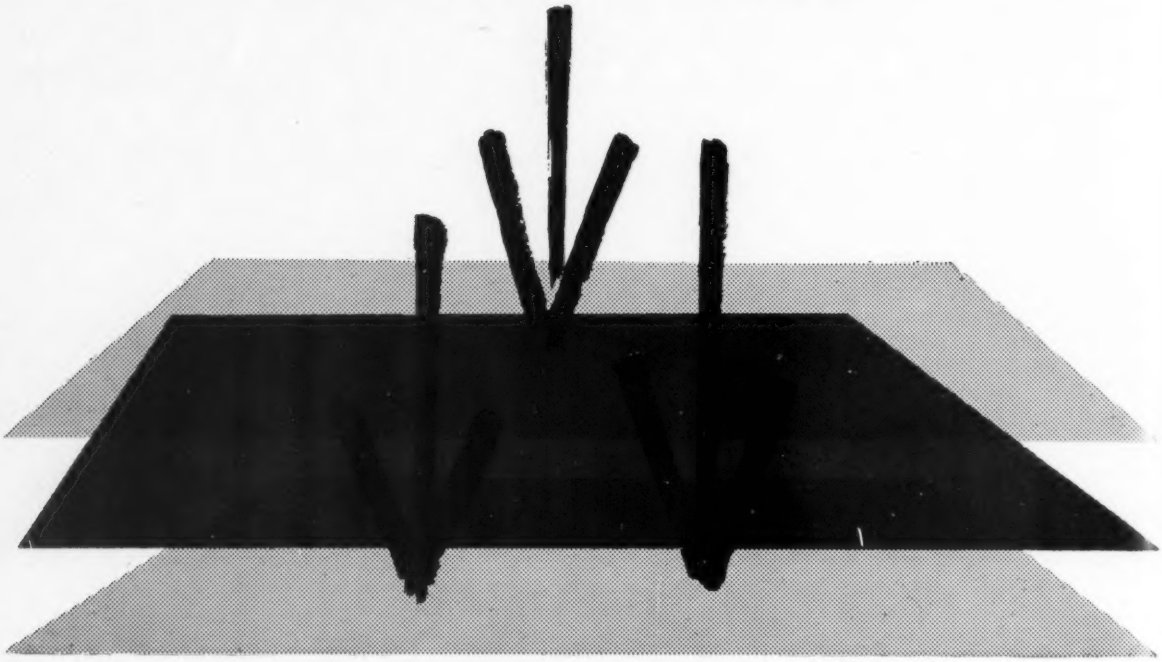

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The American Scene

(*Concluded from page 335*)

higher temperatures where reduction is more complete. Employing a radically different approach, Battelle engineers have been able to produce 98 to 100% reduction of finely divided iron-ore feed while operating at 1,600°F., where reaction rates are high.

A process for the recovery of manganese by leaching with nitric acid, concentrating the nitrate solution, and finally decomposing the nitrate to produce manganese oxide was considered unsatisfactory because the drum drier used for decomposition could not be controlled to give a uniform product. Battelle engineers fed the nitrate solution into a fluidised bed and recovered a free-flowing oxide product containing only 0.02% residual nitrogen.

$

Olin Mathieson Chemical Corporation recently completed plans for a $30-million expansion programme in organic and inorganic chemicals. It includes:

(1) Construction of new facilities at the corporation's Brandenburg, Ky., plant for production of glycerine, epichlorohydrin, propylene oxide, propylene glycol and polypropylene glycols.
(2) Expansion of existing facilities at Brandenburg to double production of *Poly-Solv* glycol ethers, *Poly - Tergent* surfactants and ethylene dichloride.
(3) Construction of a new facility to produce sulphamic acid at Joliet, Ill.
(4) Improvement of chlorine production facilities at Niagara Falls, N.Y.

The glycerine and epichlorohydrin plants, to be completed early in 1961, will use a new process developed in Olin Mathieson laboratories. The company expects demand for glycerine and epichlorohydrin to be approximately 335 million lb. p.a. in the 1963-64 period. Current total demand for natural and chemically synthesised glycerine and epichlorohydrin is about 250 million lb. p.a.

Plans for expansion at Niagara Falls, completed in May, take account of a new electrolytic cell for chlorine production. The new cells will occupy less space than those presently in use and will make possible an increase in chlorine tonnage.

In addition to this expansion programme, Olin Mathieson last month announced that it is also investing $4 million as its share in a joint venture with Sun Oil Co. to produce urea at North Claymont, Del. This project is described in CHEMICAL & PROCESS ENGINEERING this month.

$

A self-contained, 4,000-gal./day distilling unit using sea water as raw stock has been designed and constructed for the U.S. Navy by Badger Manufacturing Co. The electrically-powered prototype unit operates on a forced-recirculation vapour-compression process and is the forerunner of a unit designed to deliver 1 million gal./day of fresh water, powered by either electricity or steam. The prototype unit has delivered well in excess of its designed capacity of 167 gal./hr. of distilled water.

The essential components are a reboiler, a flash tank which separates the water-vapour from the residue, a vapour compressor, heat exchangers, a vacuum pump and various motors and control devices. The entire unit is mounted on one base.

$

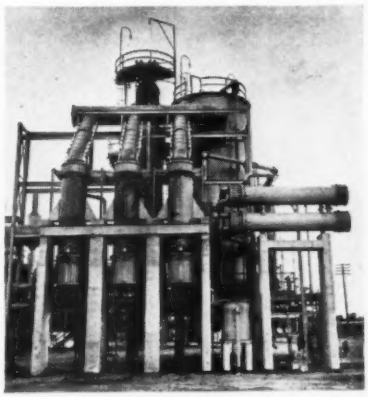
The Tennessee Valley Authority has now been in existence for over a quarter of a century and a recent review of its activities reveals that, between 1934 and 1958, it has carried out research and development work on more than 25 fertiliser materials. By 1958, the unique Muscles Shoals, Ala., development centre was turning out several varieties of fertiliser with multiple nutrients and high plant nutrient content.

In the course of its work it has been granted 113 patents, of which 90 were on fertiliser and munitions developments, 13 on mineral developments and 10 on miscellaneous inventions. Licences for the use of patented processes and equipment are granted to industries on a royalty-free, non-exclusive basis and 144 of these had been granted to 122 different companies. These included licences to firms manufacturing equipment of T.V.A. design, as well as companies using equipment or processes. Some 150 plants are now using such processes.

Electric furnaces have been developed for the smelting of phosphate rock, this method having been chosen partly because it seemed suitable for development and partly because it could be used for treating lower-grade material and for producing elemental phosphorus as an intermediate product in fertiliser manufacture. Among other outstanding equipment developments have been a simple and economical cone mixer to combine phosphate rock and phosphoric acid and a continuous ammoniator-granulator. The latter has been installed in well over 100 plants.

Among the many fertiliser materials recently investigated have been, for instance, calcium metaphosphate which has been developed into a cheaper and better product through improvement in the production plant and an increase in the standard grade to 63—64 P_2O_5. A new super-phosphoric acid with a nutrient content 40% greater than conventional phosphoric acid is being used experimentally in the industry to develop a high-analysis liquid fertiliser and, within T.V.A., to make a new and better grade of dry superphosphate material. Ammonium nitrate diammonium phosphate, combining nitrogen and phosphate nutrients in a 74% analysis, and ammonium phosphate-nitrate are other fertilisers developed to meet the diversity of demand from present-day agriculture.

A description of the chemical engineering work involved in some of the T.V.A. fertiliser projects was given in CHEMICAL & PROCESS ENGINEERING, 1956, **37** (3), 96-98.



Three of the biggest 'Karbate' impervious-graphite shell and tube heat exchangers are now being used by Olin Mathieson for recovering sulphuric acid from petroleum-refining acid sludge. Operated vertically and in parallel flow with each other, the exchangers were supplied by Union Carbide International Co.

Polish nuclear reactor project

Proposals have been approved for the establishment of a second research reactor in Poland. It is to be a hydrogen-cooled, graphite-moderated reactor with high-tension neutron stream, working on highly enriched uranium. Plans have been drawn up in consultation with Russian designers.

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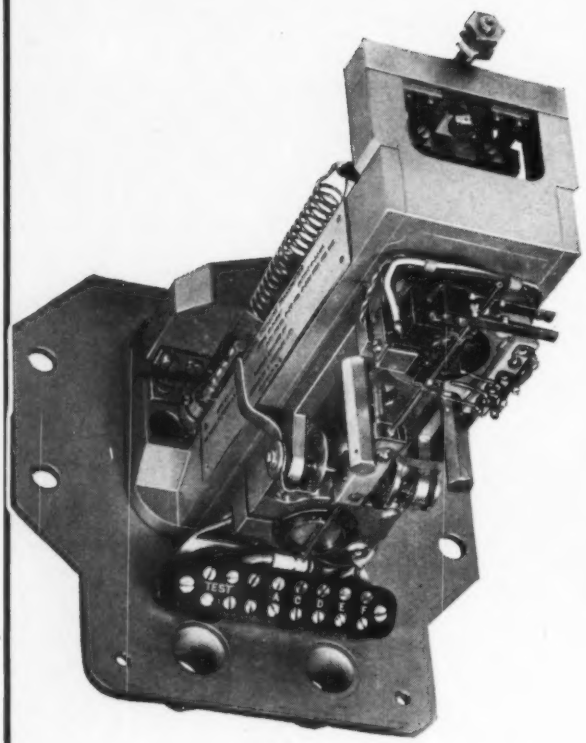

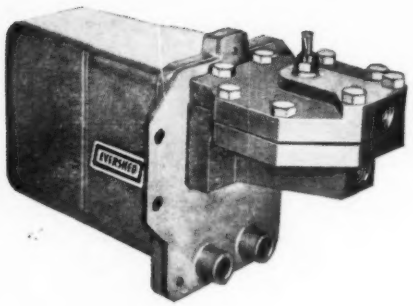

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New Books

Metal fatigue

Modern engineering design trends towards reduced safety factors and increased operational machine - part speeds make the fatigue strength of metals one of their most important mechanical properties—certainly as far as the engineering designer is concerned. This book* was prepared to present to him the known facts about fatigue and its effect upon design.

It is based on a week's residential course on the 'Fatigue of Metals' held in the Engineering Department of Nottingham University in September 1955. Each of the 20 chapters represents a lecture, which was not altered for publication purposes except that, where reference was made in the original lecture to other published work, the salient points have been included in the text and the appropriate literature references given at the end of each chapter.

This collection of papers written by authorities in universities, industry, research associations and government departments is grouped into three parts: (*a*) the fundamentals of fatigue, (*b*) the fatigue properties of engineering materials and components, and (*c*) fatigue testing of engineering components. Bearing in mind that this is not a textbook but is a collection of lectures designed to meet the requirements of the engineering designer, the book has achieved its aims. It is a pity, however, that we have had to wait since September 1955 for it to appear in print, particularly when so much can happen in four years in a field of such rapidly growing importance. H. A. HOLDEN

**Metal Fatigue*, edited by J. A. Pope. Chapman & Hall, London, 1959. Pp. 381, illus., 70s.

Reactors reviewed

In this compact little volume,* Dr. Galavanov has presented a very concise survey of the whole field of nuclear reactors. There is an introduction *via* atomic structure, radioactivity and nuclear reactions, leading up to reactor theory. The various types of reactors are discussed. Then, under the heading of 'Experimental Reactors,' the first Soviet installations are described and compared with such American types as S.T.R., *Hypo* and E.B.R., the British *Bepo* and *Dido* and the French *Cyrano*. There is an appraisal of the possible designs for power generation and some interesting speculations on reactors for propulsion of surface ships, submarines, locomotives and aircraft. Consideration is given to the uses of radioisotopes for industrial, agricultural and medical purposes. The final chapter deals with thermonuclear power, and there is a small but useful bibliography of references to Soviet literature on atomic energy.

Although the illustrations are not too well reproduced, they are all that can be expected in a book of such small size and very modest price (the English price is 2s. 6d.). F. R. PAULSEN

**Yadernye Reactory* (*Nuclear Reactors*), by E. M. Galavanov (Military Publication of the Ministry of Defence, U.S.S.R., Moscow, 1959). Pp. 212, 3Rb. 30kp.

Unit operations

This book* is primarily intended as an introductory text for students in chemical engineering and related professions; it presents material that must be mastered before the study of unit operations and thermodynamics is begun. However, the most important aspects of physical operations are thoroughly discussed: fluid flow, heat transfer, distillation, solvent extraction, gas absorption, filtration, crystallisation, etc.

In each chapter there are problems which the student can solve for himself. The text, together with the diagrams and graphs, are set out with the clarity typical of American textbooks in general.

**An Introduction to Chemical Engineering*, by Littlejohn and Meenaghan. Reinhold Publishing Corporation, New York, 1959. Available from Chapman & Hall, London. Pp. 271, illus., 63s.

U.S. chemical processes

This is the fifth volume* in a series that describes American chemical technology in pertinent detail; it deals with 14 recently developed chemical processes now in operation. Descriptions include: background, commercial and technical history and origin of present installation, design details of non-standard items, process and operation of plant; economics of the process including raw materials and processing cost statistics, plant investment and amortisation, personnel and future prospects.

This volume, together with the other four, can be regarded as reference works of the latest and most modern production methods in the chemical and process industries in the U.S.

**Modern Chemical Processes*, Vol. 5. Reinhold Publishing Corporation, New York, 1958. Available from Chapman & Hall, London. Pp. 154, illus., 40s.

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All about inks

A new book* on printing-ink technology should be a real help to the chemist or technician entering the ink-making industry as well as being a valuable guide to raw-material suppliers and all concerned with printing.

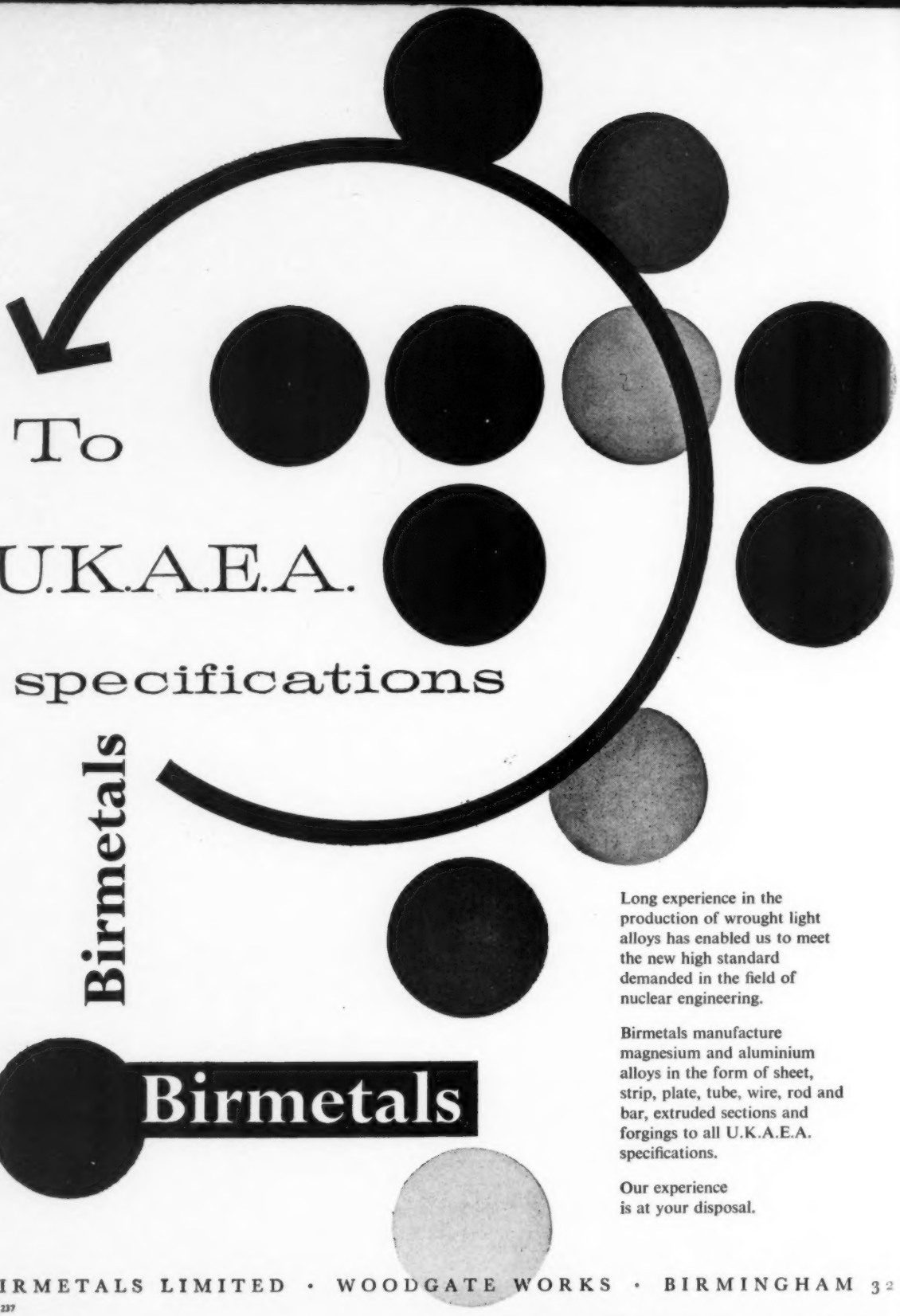
The first 16 chapters deal with raw materials and test methods. After an introductory chapter on the nature of printing, the uses of drying oils, driers, resins, waxes, solvents, diluents, plasticisers and additives are each dealt with in succeeding chapters. Considerable attention is given to factors affecting the selection of such materials for use in printing inks.

Three chapters on the properties of pigments are followed by advice on the suitability of pigments and resins for inclusion in various types of printing ink formulations. Sections devoted to colour, colour matching and laboratory testing apparatus are followed by descriptions of routine tests to be carried out in printing ink laboratories. These are followed by an admittedly compressed account of the analysis of inks.

A further three chapters are concerned with the colloidal nature of inks, ink drying and the principles of formulation. There are also chapters on the numerous kinds of inks, including special inks, and on various aspects of printing technology.

Numerous diagrams, equations, chemical formulae and samples of colour printing are dispersed throughout the text. Typical formulations for various kinds of inks are given. Sizes of type, standardisation of paper, sizes of printing papers, and a glossary of printing terms are given in appendices.

**Printing Ink Technology*, by E. A. Apps. Leonard Hill (Books) Ltd., Eden Street, London, N.W.1., 1958. Pp. 574 inc. index. Illus., 70s.



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World News

FRANCE

Nuclear Convention in force

It has been reported from Paris that the O.E.E.C. Convention on the Establishment of a Security Control in the Field of Nuclear Energy, which is designed to ensure, in particular, that joint nuclear facilities developed with the help of the Organisation are used exclusively for peaceful purposes, has entered into force. The Convention was signed by all O.E.E.C. member countries on December 20, 1957.

The operation of the control system will be the responsibility of the O.E.E.C. European Nuclear Energy Agency. This control is based on inspection of plant and the maintenance of accounts of all fissionable materials used or produced, and E.N.E.A.'s first task will be the preparation of control regulations and the setting up of an international control bureau, including the appointment of an international inspection team. The Control Convention provides for certain sanctions to be applied for failure to comply with its requirements, subject to the right of the government or undertaking concerned to appeal to a special international tribunal.

MEXICO

Citric acid plant

Official approval has been given to the project, presented by a group of sugar refiners, for the construction of a citric acid plant between Cordoba and Orizaba in Vera Cruz with an annual output of 2,500 tons.

Titanium dioxide

A new industry, Pigmentos y Productos Quimicos, has been created for the production of titanium dioxide. Some 60 million pesos will be invested in the company by the Sistema Bancos de Comercio and the U.S. firm, Du Pont.

The new industry will be in the port of Tampico and will also include a sulphuric acid plant that will use Mexican sulphur. It is estimated that production will start next April and that from then on Mexican imports of titanium dioxide will cease.

INDIA

Sulphuric acid

A 12,000 tons p.a. sulphuric acid plant at Bhilai is expected to start production soon. It will supply acid to the nearby coke-oven by-product plant for use in the production of ammonium sulphate. The plant for the conversion of by-product ammonia into ammonium sulphate is also due for completion and commissioning shortly.

The coke-oven battery commissioned in February this year is producing about 1,100 tons/day of coke and this will be doubled with the commissioning of the second battery.

CHINA

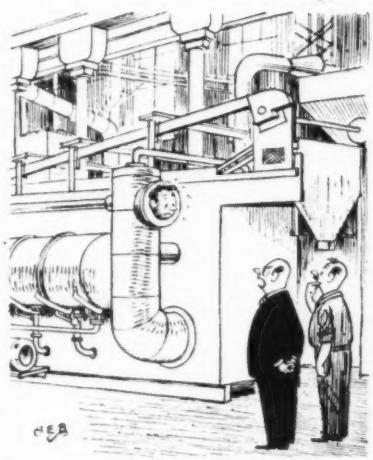
Heavy chemicals

A new sulphuric acid works has begun production in Sining, Chinghai Province; a second is to be built there later this year. The first phase of construction of the Szechwan chemical works, Kintang County, near Chengtu, is nearly complete. This will provide an annual capacity of 240,000 tons of sulphuric acid, 290,000 tons of ammonium sulphate and 55,000 tons of ammonium nitrate.

Three new plants producing calcium-magnesium-phosphorus fertiliser have gone into partial operation in the Anking area of Anhwei Province.

The Chalhan potassium fertiliser plant in Chinghai Province is said to have achieved a further increase in output. The Taiyuan Chemical Works has also gone into partial operation; its products include sulphuric acid, hydrochloric acid, caustic soda, benzene powder, DDT and 666. The Shanghai Insecticide Factory, the biggest liquid insecticide plant in China, has begun production.

Comical Engineering Corner



"IT'S CARELESSNESS LIKE THIS, WILLIAMS, THAT CAUSES TROUBLE WITH THE INSPECTOR OF FACTORIES"

GREAT BRITAIN

Corrosion Exhibition, 1960

The biggest step yet in the history of the Corrosion Exhibition will be taken with next year's show. From the Royal Horticultural Hall it is being promoted to Olympia where the whole of the Empire Hall has been booked. This means that the 1960 Corrosion Exhibition will be twice as big as the 1959 show, held last April. Stands will be bigger and there will be more and better facilities for visitors.

The Exhibition will be open from Tuesday, November 29, to Friday, December 2. A complete range of anti-corrosion materials, methods and equipment will once again be displayed.

The Corrosion Exhibition is organised by *Corrosion Technology*, a Leonard Hill journal. Bookings are now being accepted and full information is available from the Organiser, Corrosion Exhibition, Leonard Hill House, Eden Street, London, N.W.1.

PERU

Caustic soda

Alcalis Peruana S.A., a subsidiary of W. R. Grace & Co., New York, recently began construction of their chemical manufacturing plant at Paramonga. It is to be built in two stages, at a total cost of some U.S.$8 million. The first stage, due for completion by the middle of 1960, will permit a daily production of 25 tons of rayon-grade caustic soda, 22 tons of chlorine and 2 tons of bleaching powder and the second stage, to be completed by 1962, will enable this output to be doubled.

U.S.S.R.

Chemical works reconstruction

Ambitious plans for the reconstruction and re-equipment of some 200 industrial plants in the Moscow region include modernisation of the Voskresensk chemical works so as to double its output of phosphate fertilisers without any increase in the labour force.

To build a new plant with an output equal to that of Voskresensk would cost an additional 250 million roubles and would take three years longer.

Skilled chemical workers

The chairman of the State Committee for Vocational and Technical Training under the U.S.S.R. Council of Ministers has stated that he believes the number of skilled workers being trained for enterprises of the chemical industry should be increased to at least 20,000 or 25,000 by 1965, as against the present figure of between 3,000 and 3,500.

Personal Paragraphs

★ **Sir Henry Jones,** Deputy Chairman of the Gas Council since February 1952, has been appointed to succeed **Sir Harold Smith,** K.B.E., as Chairman on January 1, 1960. He is a member of a family which has held high engineering and administrative posts in the gas industry for nearly 125 years. He took an engineering degree at Cambridge, was articled to the late Sir George Evetts, and later became his assistant. Before the war he was engaged in integrating gas companies into more economic units. When the gas industry was nationalised ten years ago Sir Henry became Chairman of the East Midlands Gas Board where he remained until 1952, when he became Deputy Chairman of the Gas Council. He received his knighthood in the 1956 New Year Honours List. He is a director of the National Industrial Fuel Efficiency Service, the British Coke Export Sales Corporation, Benzole Producers Ltd. and the Association pour l'Utilisation du Coke en Scandanavie.

★ **Mr. B. E. A. Vigers** has relinquished the position of assistant managing director of Laporte Industries Ltd. and has been appointed a deputy chairman of the company and technical director of the Laporte Group.

★ **Mr. D. C. M. Salt,** director of sales, has been appointed alternate to **Mr. J. W. Urban** on the board of Monsanto Chemicals Ltd. Mr. Salt joined Monsanto in 1935, was appointed general manager of sales in 1956 and, before his recent appointment, was general manager of Chemicals Division.

★ **Mr. W. T. Newton,** a director of Woodall-Duckham (Australasia) Pty. Ltd., died suddenly in Melbourne recently. He was 56.

Mr. Newton joined the Woodall-Duckham Co., London, in 1923 and remained with the company until 1949 when he became Divisional Engineer of the Walsall and District Division of the West Midlands Gas Board. In 1953 he joined Woodall-Duckham (Australasia) as chief sales engineer and was appointed to the board in 1955.

★ **Mr. E. P. Jenkins,** a director of Robert Jenkins & Co. Ltd., died recently. He was the second son of Mr. E. J. Jenkins and brother of the present chairman and managing director, Mr. A. R. Jenkins. He joined the company in 1933, and was elected to the board in 1947.

★ **Mr. P. H. R. Lane** has been made head of a new members' service department of the British Welding Research Association. **Mr. R. G. Burt,** O.B.E., hitherto chief development officer, remains with the Association as development consultant.

★ **Mr. J. P. Elliott,** secretary and director of Davey, Paxman & Co. Ltd., has been appointed assistant managing director. He joined the company in 1943 as secretary and chief accountant and was appointed to the board in 1950.

★ **Mr. F. W. Stokes** has been appointed to the board of Powell Duffryn Carbon Products Ltd.

He joined the company in 1951 and was appointed works manager in 1954. He has been closely concerned with the development of the company's activities in machining graphite for nuclear energy.

★ The U.K.A.E.A. have appointed **Mr. J. B. Adams** to be Director of a new establishment to deal with controlled thermonuclear research. The work in this field now being done at Harwell, and some of the work now being done at A.W.R.E., Aldermaston, will be moved to this new establishment, the site of which has not yet been decided.

Mr. Adams, 39, is at present Director of the Proton-Synchrotron Group of the European Council for Nuclear Research (C.E.R.N.) near Geneva. He will take up his appointment with the Atomic Energy Authority towards the end of 1960. Mr. Adams went to the Ministry of Supply during the early days of the Atomic Energy Project and from 1946 to 1953 worked at Harwell, where he was a member of the team which designed and built there the 110-in.-diam. cyclotron.

Technology Notebook

Chemical engineering at Bradford

The Bradford Institute of Technology's course in chemical engineering has now been recognised for the award of the Diploma in Technology. The Institute has issued a leaflet outlining this course and also its full-time, post-graduate courses in chemical engineering for graduates in chemistry (Higher National Certificate or equivalent) and mechanical engineering, as well as the three-year, full-time London External Degree.

Technical organisation in rubber works

A two-day conference to discuss industrial technical organisation will be held by the Institution of the Rubber Industry at Southport on October 9 and 10. Full details can be obtained from the secretary of the Institution at 4 Kensington Palace Gardens, London, W.8.

Instruments and atomic power

The Institution of Electrical Engineers are organising a convention on the impact of nuclear development on electricity supply and on instrument techniques, to be held in London in September 1961.

Among the subjects discussed will be present and future energy requirements in relation to energy resources available; economics; operating characteristics; the siting of nuclear power stations and its effect on system planning; health physics; radiation detectors; pulse circuits; nuclear measuring instruments for research, processing control, and for prospecting and mining applications; instruments for nuclear reactors and associated plants; and data processing for nuclear applications.

Laboratory nucleonics courses

Part-time and full-time courses in nucleonic techniques and measurements will be held at Borough Polytechnic, London, starting in October. Further information and application forms can be had from the Secretary, Borough Polytechnic, Borough Road, London, S.E.1.

Explosion warning device

An explosion detector designed by the Stockholm firm of Salén & Vicander A.B. is based on the principle that platinum reacts as a catalyser when it comes into contact with explosive gases. The flame-protected 'heart' of the device is a platinum filament serving as a conductor for an electric current. When it is exposed to explosive gases the electric resistance of the metal changes and this change is transmitted to remotely situated electronic apparatus which actuates an audio or visual alarm.